Land Capability Classification System for Forest Ecosystems in the Oil Sands, 3rd Edition

Volume 1: Field Manual for Land Capability Determination

Prepared for

Alberta Environment

By the Cumulative Environmental Management Association

Alberta
Environment

2007-03630/

Land Capability Classification System for Forest Ecosystems in the Oil Sands, 3rd Edition

Volume 1: Field Manual for Land Capability Determination

Pub. No. *T/875*
ISBN: *0-7785-4641-1* (Print version)
ISBN: *0-7785-4642-X* (Online version)
Website: www.gov.ab.ca/env/

Disclaimer: Any mention of trade names or commercial products does not constitute an endorsement or recommendation for use.

Any comments, questions or suggestions on the content of this document may be directed to:

Regional Services, Northern Region

Alberta Environment

#111 Twin Atria Building

4999 – 98 Avenue

Edmonton, Alberta

T6B 2X3

Fax: (780) 427-7824

Additional print copies of this document are available from:

Information Centre
Alberta Environment
Main Floor, Oxbridge Place
9820-106 Street
Edmonton, Alberta T5K 2J6
Ph: (780) 427-2700
Fax: (780) 422-4086
Outside of Edmonton dial 310-0000 for toll-free connection
Email: env.infocent@gov.ab.ca

Copyright in this publication, regardless of format, belongs to Her Majesty the Queen in right of the Province of Alberta. Reproduction of this publication, in whole or in part, regardless of purpose, requires the prior written permission of Alberta Environment.

© Her Majesty the Queen in right of the Province of Alberta, 2006.

Contents

Glossary		i
Purpose of manual and statement of limitations		1
1.0	**Manual approach**	**01**
1.1	Assumptions and boundaries	01
2.0	**Land Capability Classification System**	**02**
2.1	Land Capability Classification System Principal Horizons	03
2.1.1	Natural mineral soils	03
2.1.2	Natural organic soils	04
2.1.3	Reclaimed soils	04
2.2	Land capability classes	05
2.3	Land capability subclasses	06
2.3.1	Subclass notation	07
2.3.1.1	General notation	07
2.3.1.2	Detailed notation	08
3.0	**Soil inventory requirements**	**09**
3.1	Sampling design	09
3.2	Sampling intensity	12
3.2.1	Survey intensity level	12
3.2.2	Inspection and sampling densities	13
3.2.3	Baseline (pre-disturbance) evaluation	13
3.2.4	Reclamation (post-disturbance) evaluation	14
3.3	Sampling methods	17
3.4	Analytical requirements	18
3.5	Landscape and soil features	20
3.5.1	Site description	20
3.5.2	Soil profile description	20
3.5.2.1	Horizon designations	21
3.5.2.2	Horizon depth and thickness	21
3.5.2.3	Water permeability	21
4.0	**Land capability rating**	**22**

4.1	Land Capability Rating Determination Overview	23
4.2	Soil Moisture Regime (SMR) Index: Subclass W or X	25
4.2.1	SMR Index Determination Where Water Table >100 cm	25
4.2.1.1	Profile AWHC	25
4.2.1.1.1	Organic modifier – Subclass O	27
4.2.1.1.1.1	Surface organic	28
4.2.1.1.1.2	Buried organic	28
4.2.1.1.2	Stoniness modifier – Subclass P	29
4.2.1.1.3	Impermeable layer modifier – Subclass Z	29
4.2.1.2	Layering modifiers	30
4.2.1.2.1	Impermeable subsoil	31
4.2.1.2.2	Coarse over fine material stratification	32
4.2.1.2.3	Fine over coarse material stratification	32
4.2.1.3	Landscape Modifier	34
4.2.1.4	Adjusted AWHC (water table >100 cm)	35
4.2.2	SMR Index Determination Where Water Table ≤100 cm	35
4.2.2.1	Natural Soils	35
4.2.2.2	Reclaimed Soils	36
4.3	Soil Nutrient Regime (SNR) Index: Subclass F	39
4.3.1	Total Organic Carbon and Total Nitrogen	39
4.3.2	C:N Ratio	39
4.3.3	Nutrient Retention Factor	40
4.3.4	SNR Cumulative Rating	40
4.4	Limiting Factor Deductions	42
4.4.1	Soil Structure: Subclass D	42
4.4.2	Soil Reaction (pH): Subclass V	47
4.4.3	Soil Salinity (EC): Subclass N	48
4.4.4	Soil Sodicity (SAR): Subclass Y	49
5.0	**Mapping Applications**	**51**
6.0	**References**	**52**

Tables

1	General subclass approach examples	08
2	Acceptable sampling designs for pre- and post-disturbance assessments	11
3	Criteria for identifying survey intensity levels[1]	15
4	Guidelines for conducting soil surveys relative to development and reclamation	16
5	Required soil analyses by principal horizon for land capability determination for pre- and post-disturbance soils	19
6	Available water holding capacity multipliers (mm cm^{-1}) by texture for natural and reclaimed soils	26
7	Summary of boundary conditions for the application of layering modifiers[1]	33
8	Landscape adjustments according to aspect and slope position for slopes ≥10 %	35
9	Guide to determining soil moisture regime	37
10	Carbon, nitrogen, C:N, and nutrient retention assigned ratings and SNR indices	41
11	Structure type, kind, class, size (CanSIS, 1983) and corresponding deductions for topsoil and subsoil	45
12	Wet, moist, and dry consistence from CanSIS (1983) and corresponding deductions for topsoil and subsoil	46
13	Topsoil and subsoil reaction deductions for soil pH (measured in H_2O)	47
14	Linear functions for calculation of percent deductions for SAR	50
15	Mapping conventions regarding polygon size	51
16	Mapping conventions to indicate purity of soil polygons	51

Figures

1	Schematic diagram of principal horizons applied to idealized natural and reclaimed soil profiles	05
2	Schematic diagram of land capability rating process	24
3	Slope positions and corresponding deductions	34
4	Soil salinity deductions	48
5	Soil sodicity deductions	49

Examples

1	Profile AWHC for a natural mineral soil profile with no limitations	27
2	Profile AWHC for a reclaimed profile with surface organic material	28
3	Profile AWHC for a reclaimed profile with buried organic material	29
4	Profile AWHC for a reclaimed mineral profile with coarse fragments	29
5	Profile AWHC for mineral profile with an impermeable layer	30
6	Where impermeable layer occurs within the profile, any underlying material does not contribute to the AWHC	30
7	Profile AWHC for a natural mineral soil with a shallow bedrock	31
8	Profile AWHC for a natural mineral soil with coarse over fine material stratification in the subsoil	32
9	Profile AWHC for a reclaimed mineral soil with fine over coarse material stratification in the subsoil	33
10	Calculating TOC (Mg ha^{-1}) for a 0.20 m-thick topsoil horizon with a bulk density of 1.0 Mg m^{-3} and a TOC content of 4.0%.	39
11	Calculating total nitrogen (Mg ha^{-1}) for a 0.20 m-thick topsoil horizon with a bulk density of 1.0 Mg m^{-3} and a total nitrogen content of 0.20%	39
12	Calculating C:N ratio for the topsoil *plus* L,F and H horizons of a soil with TOC of 52.6 Mg ha^{-1} and total nitrogen of 3.4 Mg ha^{-1}	39
13	Nutrient retention ratings for TS and US horizons of a natural soil	40
14	Structure and consistence deductions for a natural soil	44
15	Soil reaction (pH measured in H_2O) deductions for a reclaimed soil	48

16	Soil salinity (EC) deductions for a reclaimed soil	49
17	Soil sodicity (SAR) deductions for a reclaimed soil	50

Equations

1	Land Capability Classification Systems general equation	03
2	Adjusted AWHC	35
3	Soil salinity deductions for EC of 2 to 8 dS m^{-1}	48

Appendices

A	Soft-spots list
B	Suggested reclaimed horizon designations
C	Site and soil description form
D	Land capability worksheet
E	Example site and soil description and land capability worksheet

GLOSSARY

Aggregates: The arrangement of individual soil particles into compound particles which are separated from adjoining compound particles (aggregates) by planes of weakness through processes of soil development.

Athabasca oil sands region: Generic description of a subsection of the Boreal Central Mixedwood region of northeastern Alberta, centered roughly on the zone of surface oil sand mining, north of Ft. McMurray and on both sides of the Athabasca River.

AWHC or Available water holding capacity: The difference in soil water content, typically measured volumetrically, between "field capacity" (typically -10 or -33 kPa of matric potential, depending on soil texture) and "permanent wilting point" (-1500 kPa of matric potential).

Capping depth: The thickness of soil material or "cap" placed on a given substrate as part of reclamation activities.

Capping: A reclamation activity where a reclaimed structure or area with a given substrate is reclaimed by placing a "cap" of soil material at the surface.

Commercial forest: A forest ecosystem producing trees of sufficient size/quality to enable commercial recovery of their stems for pulp or sawlogs.

Control section: The vertical section upon which soil classification is based. The control section usually extends to a depth of 100 cm in mineral materials and to 160 cm in organic materials.

Cretaceous Clearwater material: Saline-sodic clay shale of the Cretaceous period (~100 million year before the common era).

Cretaceous McMurray material: Bitumenous sands (a.k.a. oil sand, tar sand). The sand having been deposited during the Cretaceous period (~100 million years before the common era).

Ecosystem productivity: The ability of an ecosystem to produce, grow, or yield biomass (total living matter).

Edaphic: Of or pertaining to the soil.

Edatope: Soil moisture/nutrient grid that displays the potential ranges of combinations of moisture (very dry to wet or xeric to hydric moisture regimes) and nutrient (very poor to very rich) conditions (adapted from Beckingham and Archibald, 1996).

Edatope position: A location on the edatope, as defined above, delineating a specific combination of soil moisture and nutrient conditions.

Equivalent land capability: The ability of the land to support various land uses after conservation and reclamation similar to the ability that existed prior to an activity being conducted on the land. The individual land uses will not necessarily be identical (Province of Alberta, 2003).

Footprint: The area of land occupied by an industrial disturbance.

Fragments: Pieces of non-soil (*e.g.*, geologic) material that has fractured along planes of weakness.

Horizon: A layer of mineral or organic soil material approximately parallel to the land surface that has characteristics altered by processes of soil formation (Soil Classification Working Group, 1998).

Impermeable: A substance that cannot be permeated by water.

Land capability rating: The product, on a scale of 0 to 100 points, of the integration of numeric values assigned to soil and landscape characteristics as described in this LCCS. The land capability rating replaces the soil and landscape ratings from previous editions of this document.

Material salvage: The process of physically removing soil from the pre-disturbance landscape for use in reclamation activities.

Mineral horizon/material: Material having 17% or less total organic carbon by weight.

Natural soils: Those soils not severely disturbed by industrial activities such as surface mining, aggregate mining, or oil/gas extraction. Soils may still be described as pre-disturbance/natural soils after experiencing less severe disturbances resulting from industrial activities such as forest harvest.

Organic horizon/material: Material having more than 17% organic carbon by weight.

Parent material: The unconsolidated and more or less chemically weathered mineral or organic matter from which the solum of soils developed by pedogenic processes (Brady and Weil, 1996).

Peat:mineral mix: A combination of organic and mineral soil that is typically achieved by over-stripping organic deposits during material salvage or by mechanical incorporation post-placement.

Pedon: A real unit of soil; the smallest homogenous, three-dimensional unit that can be considered a soil.

Polygon: From mapping conventions - refers to a unit of land identified for land capability assessment and is typically large enough to be mapped at the desired/required scale. Ideally polygons are stratified prior to assessment based on known characteristics to reduce variability.

Principal horizons: The LCCS principal horizons include the topsoil (0-20 cm), the upper subsoil (20-50 cm) and the lower subsoil (50-100 cm). Properties of horizons or strata existing in each of these principal horizons are weighted differently.

Reclaimed: Reconstructed soils resulting from some form of soil salvage and replacement, where the "soil" materials themselves (*e.g.* tailings sand) or their horizonation has been anthropogenically altered.

Sodium adsorption ratio: the comparative concentrations of sodium, calcium, and magnesium in the soil solution, where $[Na^+]$, $[Ca^{2+}]$, and $[Mg^{2+}]$ are the concentrations in mmol of charge per litre of solution. The SAR of a soil extract takes into consideration that the adverse effect of sodium is moderated by the presence of calcium and magnesium ions. SAR values of 7 and higher cause dispersion of soils.

$$SAR = \frac{[Na^+]}{(0.5[Ca^{2+}] + 0.5[Mg^{2+}])^{1/2}}$$

Soil conservation: The planning, management and implementation of an activity with the objective of protecting the essential physical, chemical and biological characteristics of the soil against degradation (Province of Alberta, 2003).

Soil moisture regime index: Each soil moisture regime class is assigned a numerical index for use in this LCCS to determine the land capability rating. The integration of numerical values

assigned to individual soil and landscape characteristics as described in this document determines the soil moisture regime index for a given site.

Soil moisture regime properties: For the purposes of land capability determination, these include depth to water table, slope percent, slope type, aspect, percent volume coarse fragments, horizonation, horizon thickness, soil texture, and mottles.

Soil moisture regime: The available moisture supply for plant growth on a relative scale ranging from very dry (xeric) to very wet (hydric) classes (adapted from Beckingham and Archibald, 1996). In this LCCS, it is assessed through an integration of soil and landscape characteristics.

Soil nutrient regime index: Each nutrient regime class is assigned a numerical index for use in this LCCS to determine the land capability. The integration of numerical values assigned to individual soil characteristics as described in this document determines the soil nutrient regime index for a given site.

Soil nutrient regime properties: For the purpose of land capability determination, these include percent total organic carbon, total nitrogen, soil texture and bulk density.

Soil nutrient regime: Amount of essential nutrients that are available for plant growth on a relative scale ranging form very poor to very rich (adapted from Beckingham and Archibald, 1996). In this LCCS, it is assessed through an integration of soil characteristics.

Strata: A layer of mineral or organic material that is either not soil (such as rock or water or unconsolidated material unaffected by soil forming processes) or a layer of material used in reclamation.

Substrate: The material that underlies the reclamation material cap. Typical substrates include cretaceous Clearwater formation, cretaceous McMurray formation (oil sand), and tailings sand.

Tailings sand: The coarse mineral by-product of the oil extraction process.

PURPOSE OF MANUAL AND STATEMENT OF LIMITATIONS

The goal of reclamation in Alberta is to achieve land capability equivalent to that which existed prior to disturbance. The *Land Capability Classification System for Forest Ecosystems* manual (LCCS) is a working document intended to facilitate evaluation of land capabilities for forest ecosystems on natural and re ıimed lands in the Athabasca oil sands region, as required by Alberta's Environmental Protection and Enhancement Act (EPEA) approvals, and by current Alberta Environment terms of reference for Environmental Impact Assessments. The LCCS is based on an integration of numeric values assigned to soil and landscape characteristics that are known to be fundamental to ecosystem productivity. Parameters considered include soil moisture regime, soil nutrient regime and soil physical and chemical properties that are potentially limiting to plant growth.

The first edition of the LCCS was developed in 1996 by the Tailings Sand Reclamation Practices Working Group, and was revised in 1998 based on results from field testing. The Soil and Vegetation Subgroup (SVSG) of the Reclamation Working Group (RWG) of the Cumulative Environmental Management Association (CEMA) is currently responsible for the continued refinement of the LCCS, and has developed this 3rd (2006) Edition.

Commencing in 2000, a network of long-term monitoring plots (hereafter referred to as the "Soil and Vegetation Plots") was established to refine understanding of natural ecosystems and evolution of reclaimed ecosystems. The 2006 Edition represents improvements in knowledge, particularly in soil moisture and nutrient regime determination, gained from initial characterization and analysis of plot data. This characterization and analysis has also resulted in the identification of several key areas requiring additional research and monitoring. The SVSG is managing a comprehensive work program, including ongoing assessment of the plot network, to address remaining uncertainties associated with the LCCS (note that some components of this work program are being addressed by non-SVSG industry research initiatives). Details of this program, and remaining unaddressed issues, are presented in Appendix A. As understanding of reclaimed ecosystems improves, the LCCS will be correspondingly improved (pursuant to C&R/IL/98-7 [Alberta Environment, 1998] and individual project approval conditions).

As described above, the goal of the LCCS is to provide a rating of land capability for forest ecosystems. In order to both validate and calibrate the LCCS manual's integration of numerically valued soil/landscape properties, it is intended that the LCCS ratings be indexed to measured tree growth performance. The first round of monitoring of the long-term plots has not resulted in establishment of a clear correlation between LCCS-predicted forest site productivity and measured forest site productivity, particularly on reclaimed sites. Further, reclaimed forest stands are young, and, due to the dynamic nature of stand nutrient demand, early performance may not be a reliable indicator of later growth and nutrient status. This is because regenerating stands place increasing nutrient demand on soils with increasing foliar biomass, until peak foliar biomass is attained approximately at crown closure (Ballard, 1984; Miller, 1984). Continued measurement of the long-term plot network will provide a solid basis to further determine the correlation between forest productivity and land capability classification, and provide data for reclaimed stands as they reach maturity. Because long-term performance of reclaimed sites is not fully documented or understood, there are uncertainties about the ability of minimum capping depths to successfully achieve equivalent capability for productive forests on reclaimed sites. The SVSG of CEMA is undertaking further monitoring in an attempt to resolve these uncertainties. There is no foreseeable short-term solution for this issue, and caution should be taken in relying on minimum capping depths until such time as the uncertainty is reduced.

Because the link between LCCS rating and forest productivity is currently undemonstrated, the LCCS should be considered as one in a suite of tools for site evaluation and reclamation planning, rather than a comprehensive system that alone will ensure replacement and documentation of equivalent land capabilities. Reclamation certification (*e.g.*, for a commercial forest use site) will ultimately be evaluated based on above-ground measures of site productivity as well as on the LCCS rating, and on other landscape characteristics (see Alberta Land Conservation and Reclamation Council, 1991).

This document (LCCS Vol. 1) is a field manual intended to enable determination of land capability. A complementary software tool designed to ensure correct and consistent calculation of LCCS ratings will be available shortly. In addition, a corresponding background and rationale document (LCCS Vol. 2) is under development, and will be released in the near future.

1.0 MANUAL APPROACH

This manual outlines the procedure for determining land capability rating for natural and reclaimed soils in forest ecosystems in the Athabasca Oil Sands Region of Alberta. Guidance is also provided for sampling methods and intensities.

The products of land capability determination are the land capability rating, class and subclasses, and the soil moisture and nutrient regime indices (combining to establish edatope position) for an assessed soil polygon. These can be used in conjunction with the companion document *Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region* (Oil Sands Vegetation Reclamation Committee [OSVRC], 1998) for developing revegetation treatments on reclaimed landscapes.

1.1 Assumptions and Boundaries

- This LCCS has been calibrated for and is intended for use in the Athabasca Oil Sands Region only. Use outside of this region is not supported by the issuers of this document.
- Application of this manual requires knowledge and experience in the areas of soil survey and classification. It is the responsibility of the project manager to ensure that field personnel are competent in these areas. It is strongly recommended that projects be managed by suitably qualified members of recognized professional associations.
- This LCCS is intended to evaluate equivalent land capability by comparing pre- and post-disturbance capability.
- The use of the LCCS as a tool to calculate minimum soil requirements (*i.e.*, thicknesses) necessary for the achievement of particular capability classes in the design of reclaimed soils is not recommended. Reclamation treatments should be based on knowledge of site-specific materials and objectives.
- This LCCS is used for evaluating the land capability to support upland commercial forests. This assumes that all classes are capable of providing a range of other values and end land uses.

- Lands in each class can be similar in degree, but not necessarily in kind, for limitations for forest production (*i.e.*, similarly classed lands may be produced by different limitations on different sites).
- Land capability assessment applies to the upper one metre of soil. It is the responsibility of the respective permit holders to be aware of underlying material quality.
- The climatic regime present during development of natural forest stands is assumed to be similar to that which is affecting and will affect reclaimed sites. Thus, neither climatic factors nor climate change, whether naturally or anthropogenically induced, are incorporated in the LCCS.
- This LCCS assumes that soils meet operating approval requirements and do not have characteristics that pose significant environmental risks to humans or the environment, for example potentially toxic constituents.
- The LCCS manual is a "living document" that will be refined through testing and evaluation in the field. As more experience is gained, and different natural soil and reclaimed landscapes are evaluated, the LCCS will be modified through discussions with stakeholders (C&R/IL/98-7; Alberta Environment, 1998).

2.0 LAND CAPABILITY CLASSIFICATION SYSTEM

The LCCS is an integrated soil and landscape rating calculated from key parameters including soil moisture regime (SMR) properties, soil nutrient regime (SNR) properties, and potentially limiting soil physical and chemical properties, in the three principal soil horizons (see below). SMR properties are integrated into the SMR index (ranging from 10 to 80 points) and the SNR properties are integrated into the SNR index (ranging from 0 to 20 points). The LCCS Base Rating is the sum of the SMR and SNR indices. Potential limiting factors, including soil structure and consistence, pH, electrical conductivity (EC [dS m^{-1}]) and sodium adsorption ratio (SAR), are calculated as a function of the Base Rating for each of the LCCS principal horizons and deducted from the Base Rating to give the LCCS land rating (Equation 1). The Final Land Rating determines the land capability class.

Equation 1. LCCS general equation.

Final Land Rating = Base Rating – Limiting Factor Deductions

2.1 LCCS Principal Horizons

The LCCS rating is largely based on soil properties of the one-metre soil profile. Three principal horizons are defined: topsoil (TS) 0-20 cm; upper subsoil (US) 20-50 cm; and lower subsoil (LS) 50-100 cm in the LCCS model to arrive at the land capability rating.

In the LCCS, ratings for limiting factor deductions are weighted by soil horizon: the properties of the TS horizon are weighted most heavily and incur full (100%) deductions for any applicable limiting factors; the US incurs 67 % deductions; and the LS incurs 33 % deductions.

The LCCS principal horizons are imposed on natural mineral, natural organic and reclaimed soils. The LCCS principal horizon boundaries at 20, 50 and 100 cm will not necessarily match up with the natural horizonation or the reclamation material boundaries as illustrated in Figure 1; these measurements are intended as guidelines.

Soil description and sampling for the application of the LCCS is done on the basis of soil horizon or strata. The boundary condition of 17 % total organic carbon (TOC) on a dry weight basis (Soil Classification Working Group, 1998) is adopted in the LCCS to separate mineral soil horizons from organic soil horizons (or strata).

This section presents how the LCCS principal horizons are applied to natural mineral, natural organic, and reclaimed soils. Further details for the application of the principal horizons to soils are provided in Section 3.3, Sampling Methods, and Section 3.5, Landscape and Soil Features.

2.1.1 Natural Mineral Soils

For natural mineral soils, defined as those having less than 40 cm of organic material at the soil surface, the LCCS principal horizons begin at the mineral soil surface and normally include three soil master horizons: topsoil horizons (*e.g.*, Ae, Ahe, Ah), subsoil horizons (various B horizons) and parent materials (C horizons). In general, the TS is typically comprised of natural A, AB and possible B horizons; the US is comprised of natural B, BC and possible C horizons; and the LS is comprised of natural C horizons.

Surface organic materials (*i.e.*, L, F, H, or O horizons less than 40 cm thick) are sampled separately from the mineral horizons. These organic horizons do contribute to the soil nutrient regime index determination but do not contribute to the profile available water holding capacity (AWHC) determination.

2.1.2 Natural Organic Soils

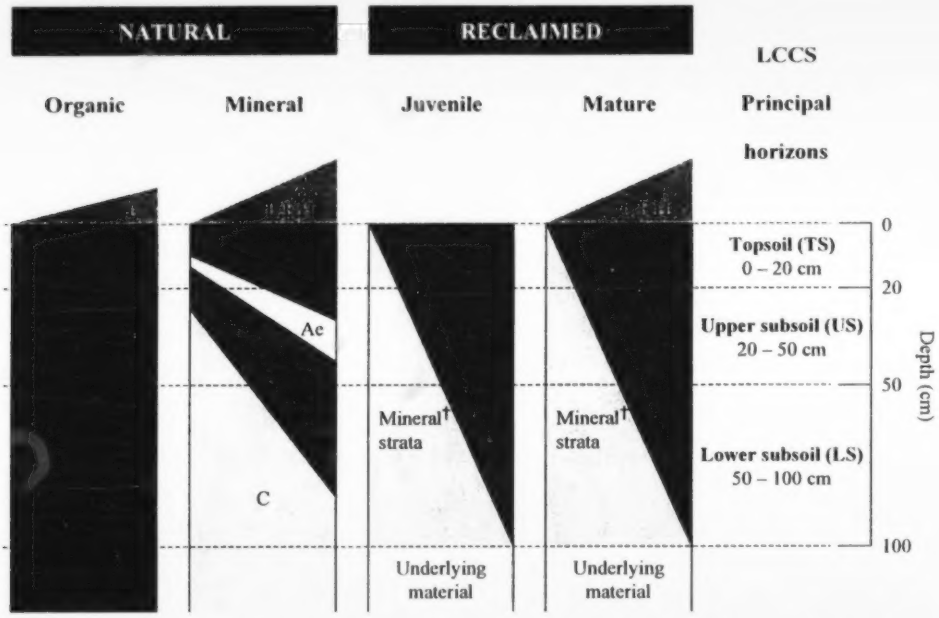
For natural organic soils, defined as those having 40 cm or more of organic material at the soil surface, the LCCS principal horizons include the surface tier (0-40 cm) and the upper 75 % of the middle tier (40-120 cm). This may include many different combinations of organic horizons (Of, Om Oh, and Oco), mineral C horizons and water (W). Soil classification of organic soils requires the investigation of all three tiers (Soil Classification Working Group, 1998).

Where L, F and/or H horizons overlay organic soil horizons (*e.g.*, O horizons), they are sampled separately. The former materials, in addition to the upper 20 cm of the underlying organic horizons, contribute to the soil nutrient regime index determination. For organic soils, soil moisture regime is determined by indicators including surface organic thickness, depth to water table, and mottles/gleying, not by the profile AWHC.

2.1.3 Reclaimed Soils

For reclaimed soils, the LCCS principal horizons normally include the reconstructed soil strata and may also include underlying mine waste materials. Reconstructed soil strata are materials salvaged from the natural landscape and can be categorized very broadly as mineral or organic-enriched.

Because it is often difficult to determine in the field whether a stratum is mineral or organic, the TS is assumed to begin at the surface of material placement (as opposed to the mineral/organic interface as in natural mineral soils).



† Mineral horizons are defined as those having less than 17% total organic carbon (TOC) determined as outlined in Table 5).

‡ Organic-enriched strata are mineral horizons containing organic matter (*i.e.*, peat/mineral mixes and shallow soil salvage). In the cases where the surface strata of a reclaimed soil or natural mineral soil with an O layer contains 17% or more TOC it is not considered to contribute to the moisture regime of the soil (see Section 4.2.1.1.1).

§ These profiles are generalizations. Each soil type presented is characterized by wide ranges of variability in horizon thickness and development.

Figure 1. Schematic diagram of principal horizons applied to idealized§ natural and reclaimed soil profiles.

2.2 Land Capability Classes

There are five classes of land recognized in the LCCS, rated according to potential and limitations for productive forest use. Classes are based on adjusted Canada Land Inventory categories, with Classes 1, 2, and 3 being capable of supporting commercial/productive forests, and Classes 4 and 5 being non-commercial/lower-productivity forest lands. The classes are an approximate assessment of the degree or intensity of limitation. For example, Class 3 land has limitations that are more severe than Class 2. The subclasses describe the kind of limitations responsible for class designation.

The classes represent an idealized generic trend of forest productivity representing 20 % difference in productivity between classes. Different tree species are not all equally adaptable to the range of moisture and nutrient regimes, and will respond differently to different soil-based limitations.

Class 1 High Capability (Final land rating 81 to 100): Land having no significant limitations to supporting productive forestry, or only minor limitations that can be overcome with normal management practices.

Class 2 Moderate Capability (Final land rating 61 to 80): Land having limitations which, combined, are moderately limiting for forest production. The limitations will result in reduced productivity or benefits, or require increased inputs to the extent that the overall advantage to be gained from the use will still be attractive, but appreciably inferior to that expected on Class 1 land.

Class 3 Low Capability (Final land rating 41 to 60): Land having limitations which, combined, are moderately severe for forest production. The limitations will result in reduced productivity or benefits, or require increased inputs to the extent that the overall advantage to be gained from the use will be low.

Class 4 Conditionally Productive (Final land rating 21 to 40): Land having severe limitations, some of which may be surmountable through management, but which cannot be feasibly corrected with existing practice.

Class 5 Non-Productive (Final land rating 0 to 20): Land having limitations that appear so severe as to preclude any possibility of successful forest production.

2.3 Land Capability Subclasses

A subclass, denoted by the letter(s) in brackets, indicates the kind of limitation, as follows:

Horizon-independent factors:

- Soil moisture regime (SMR): Very dry (X), Wet (W)
- Organic surface (O), Stoniness (P), Impermeable layer (Z)
- Soil nutrient regime (SNR): Fertility (F)

Horizon-dependent factors:

- Soil structure and consistence (D)
- Soil reaction (V)
- Soil salinity (N)

- Soil sodicity (Y)

Combination of three or more factors: (S)

2.3.1 SUBCLASS NOTATION

Two approaches to subclass notation, general and detailed, have been developed, depending on user needs. The general notations are recommended for overview purposes such as environmental impact assessments and mapping. Detailed notations are recommended for reclamation planning, management and monitoring. The general and detailed notations are not necessarily exclusive; for a single project, it may be necessary to determine both types of subclasses to meet data presentation needs.

Class 1 soils do not have subclasses. Horizon-independent subclasses "X" or "W" are applied for SMR as directed by Table 9, (subclasses O, P, and Z are applied as directed in Sections 4.2.1.1.1, 4.2.1.1.2, and 4.2.1.1.3), and "F" for "Poor" overall SNR, as calculated in Section 4.3. Horizon-dependent subclasses for limiting factor deductions are applied differently based on the approach: general versus detailed. A comparison of the general versus the detailed approach with examples is presented in Table 1.

2.3.1.1 General Notation

The general approach limits the subclass notation to two limiting factors. Where three or more limiting factors exist, the combination subclass notation (S) is applied. Notations are applied for limiting factors where they incur a total 20-point deduction for the entire profile (*i.e.*, the sum of the TS, US, and LS point deductions [b, d, and e]). For example, subclass notations can be applied for deductions incurred in a single horizon (as in Table 1, Profile 2) or for more than one horizon (as in Table 1, Profiles 1 and 3). Where the total profile deduction is less than 20 points, subclass notations are not applied (as in Table 1, Profile 4).

The advantages of the general approach are simplicity and ease in data management. The disadvantage is that the quality and location (principal horizon) of the limitation is not readily understood.

2.3.1.2 Detailed Notation

The detailed approach does not limit the subclass notation to two limiting factors, and the combination subclass notation (S) is not used. Up to six subclasses can be included with a single soil rating and the principal horizons are identified for horizon-dependent factors using numerical subscripts (see examples presented in Table 1). Notations are applied where they incur a 20-percent deduction for a principal horizon. For example, Profiles 1 and 2 (Table 1) have subclasses because the deductions were 20 % in the respective soil horizons. Profile 4 (Table 1) has subsoil point deductions (3 and 1 points respectively for the US and LS) but subclasses are not applied because these deductions were only 10 % in the respective horizons.

The primary advantage of the detailed approach is the higher resolution of limitation notations. The disadvantage is the greater complexity and corresponding increased data management requirements.

Table 1. General Subclass Approach Examples.

Rating Component (subclasses)†		Profile 1		Profile 2		Profile 3		Profile 4	
SMR index		52		80		38	(X)	38	(X)
SNR index		10		20		20		0	(F)
Base rating (SMR+SNR)	a	62		100		58		38	
TS deduction	b	12	(V)	20	(V)	12	(V)	0	
Interim soil rating	c	50		80		46		38	
US deduction	d	7	(V)	0		6	(D)	3	
LS deduction	e	3	(V)	0		3	(N)	1	
Profile deduction [Σ (b,d,e)]		22	(V)	20	(V)	21	(S)	0	
Final land rating (a-b-d-e)		40		80		37		34	
Land capability class and subclasses									
General subclass notation		**4**	**V**	**2**	**V**	**4**	**S**	**4**	**XF**
Detailed subclass notation		**4**	**V_{123}**	**2**	**V_1**	**4**	**$XV_1D_2N_3$**	**4**	**XF**

Profile 1 Entire profile affected by a 20% pH limiting factor deduction.
Profile 2 Topsoil affected by a 20% pH limiting factor deduction.
Profile 3 Each principal horizon affected by a different limiting factor deduction.
Profile 4 Profile with limiting SMR and SNR, and 10% limiting factor deductions in US & LS.

† See Land Capability Worksheet (Appendix D) for calculation details.

3.0 SOIL INVENTORY REQUIREMENTS

This section presents soil sampling designs, intensities, and methods for purpose of land capability classification of pre- and post-disturbance soils. Minimum soil and landscape data and laboratory analyses required for input to the LCCS are presented.

It is the responsibility of the project manager to ensure that required coverage and analyses are obtained, and that the input of appropriate professionals is sought to address any special circumstances beyond the scope of the specifications outlined below.

3.1 Sampling Design

The purpose of this section is to provide guidance on appropriate sampling design for the collection of LCCS data. The primary goal for sampling is to provide a representative characterization of a system or population under investigation. The identification of appropriate sampling designs is largely dependent on the purpose or objective of the assessment. Land capability classification is rarely the only objective of a field program. It is performed on pre-disturbance soils as part of Environmental Impact Assessments and on post-disturbance soils as part of reclamation assessments and monitoring. Other important considerations for sampling success include experience of the project manager and field personnel, degree of foreknowledge about the area, site accessibility, need for statistical interpretation, time and cost.

The Mapping Systems Working Group (MSWG, 1981) outlines a range of acceptable sampling designs for support of pre-disturbance mapping including free (purposive or authoritative), random, systematic and stratified sampling designs. Following is a summary of advantages and limitations of these designs (Crépin and Johnson, 1993), provided to aid in planning sampling for the collection of data for input into this land capability system. All except free survey are acceptable designs for post-disturbance evaluations.

Each of the sampling designs described below have different implications to cost, mapping, and statistical interpretation. Where the objectives of a sampling program include statistical analysis of the data, consultation with a professional statistician at the project planning stage is strongly recommended.

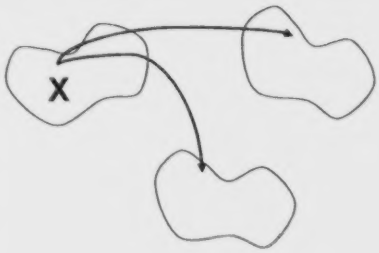
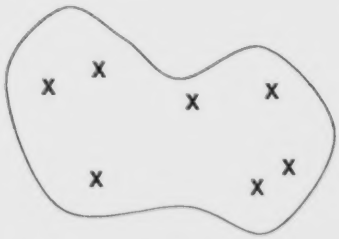
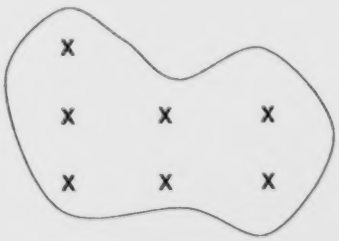
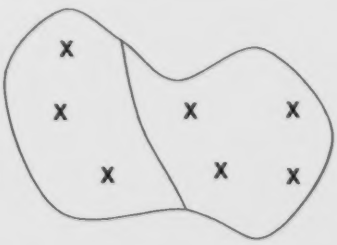
Free survey: Based on hypotheses regarding the distribution of different soils, the project manager subjectively selects sample locations and extrapolates data from sample sites to other areas considered to be similar without inspecting them. This approach can be appropriate in pre-disturbance evaluations where soil-landscape relationships are well known and where the surveyor is experienced, and is commonly used where time, cost and accessibility are significant constraints (MSWG, 1981). Probability theory cannot be applied because the design is not random and objective conclusions about the population cannot be made. However, the MSWG (1981) cite studies that have shown free survey to be "acceptably accurate" for pre-disturbance assessments. This approach is **not** appropriate on post-disturbance assessments because soil-landscape relationships are not fully known or developed, and thus subjective plot sampling may not adequately represent the full range of existing conditions.

Simple random sampling: The sampling area is divided into subunits and a randomization plan for the sampling is developed prior to field sampling. Sample sites are selected randomly according to the plan. The number of samples required can be determined from known or estimated variance. Simple random sampling is appropriate for most statistical analysis but is not frequently used for mapping.

Systematic sampling: From an initial randomly selected point, sample locations are established in a fixed pattern and interval to provide complete coverage of a soil population. If the pattern and interval match cyclical variation in the landscape, unrepresentative samples result. In this case, statistical analysis is more difficult because samples are not collected at random; therefore, a professional statistician should be consulted prior to statistical analysis of systematically collected data. Systematic sampling is rarely used in pre-disturbance soil survey (MSWG, 1981); however, it is preferred for some mapping applications and geostatistics.

Stratified sampling: Based on existing data (surficial geology, topography, vegetation interpretation, different material placement methods in soil reclamation, *etc.*) or a preliminary or exploratory survey, the total area is broken into a number of subpopulations or strata. Recognizing the strata allows partitioning of variation caused by the strata, thereby reducing the error terms used to conduct relevant statistical tests, subsequently improving the sensitivity of the test. This method is frequently used in soil survey. Within each stratum, free, random or systematic sampling can be applied.

Table 2. Acceptable sampling designs for pre- and post-disturbance assessments.

Sampling design		Natural	Reclaimed
Free survey		✓ Acceptable where soil-landscape relationships are well known and understood by Surveyor.	✗
Simple random		✓	✓
Systematic		✓	✓
Stratified		✓	✓

3.2 Sampling Intensity

For statistical applications, the number of samples required to achieve a desired level of precision in a given area is largely dependent on the variability within that area (Crépin and Johnson, 1993). For mapping projects, the purpose or end-use of the map, the total hectares of the individual map units, and the map scales for publication determine the number of sampling sites required. Sufficient samples are to be collected to properly characterize the map units. Recommended survey intensity level, mapping scales, inspection density, and sampling density are presented in Table 3 and Table 4 pursuant to guidelines presented in the *Soil Survey Handbook Volume I* (Expert Committee on Soil Survey, 1987) and the Soil Quality Criteria Relative to Disturbance and Reclamation (Alberta Soil Advisory Committee, 1987).

3.2.1 Survey Intensity Level

Soil survey intensity level (SIL) reflects the level of detail needed to properly conduct a survey project. Five levels of SIL are recognized by soil surveyors, from the most detailed (SIL 1) to the least detailed (SIL 5) (Expert Committee on Soil Survey, 1987). The SIL 1 and SIL 2 are often used at a site-specific level for environmental projects. SIL 3 is normally used for regional projects.

SIL is largely defined as the required number of field inspections per unit area, along with the precision used to delineate the boundaries between the adjacent mapping units in the field, or other estimates of accuracy. Application of a specific SIL is also related to the scope of the project, map scale, degree of natural variability in the survey area, survey techniques, and desired levels of soil taxonomy. SIL 1 surveys are tailored to identify objectives for specific operations and are commonly conducted on the disturbance "footprint" areas. SIL 2 surveys are conducted to aid in general planning, as for preliminary evaluations or in buffer areas surrounding proposed/actual disturbances. The scale of mapping is based mainly on the minimum size of field delineation. As a general rule, one inspection should be made for a field area that corresponds to approximately 1 cm^2 area on the map to be published. Table 3 provides a summary of criteria for identifying required survey intensity level. The *Soil Survey Handbook Volume I* (Expert Committee on Soil Survey, 1987) should be consulted for further details.

For example, if soil units with different use potentials must be recognized down to a size of 4 ha then the scale should be at least 1:20 000. Where reclaimed areas are very small (<16 ha), as in wellsites, the higher range of inspection density for SIL 1 is recommended. Applicable criteria should be followed for specialized applications such as wellsites, borrow pits, *etc*. For post-disturbance mapping, a scale of 1:5 000 is suggested for non-selectively handled areas or where materials-handling techniques were minimal. Where selective-handling techniques are employed, a scale of 1:5 000 or 1:10 000 is suitable.

3.2.2 Inspection and Sampling Densities

The SIL chosen for a project defines the minimum intensities/densities of inspection and sampling sites (Table 4). Two types of sites are established as part of a soil survey: sample sites and inspection sites.

Sample sites are defined as invasive (*i.e.*, soil pit) inspections where soil and landscape data and soil samples are collected for analysis. Sample sites are established according to the soil sampling density guidelines presented in Table 4. The soil and landscape data collected at sample sites and the results from chemical analyses are used to input into this land capability system. Sampling methods are presented in Section 3.3, minimum analytical requirements for input to the LCCS are presented in Section 3.4, and field data collection requirements are presented in Section 3.5.

Inspection sites are defined as invasive (*e.g.*, hand auger) inspections where select soil and landscape data may be collected but soil samples are **not** required. Inspection sites are established according to the soil inspection density guidelines presented in Table 4. The soil inspection density is always greater than the sampling density and is intended to evaluate variability between sites within soil unit or type. Inspections are intended to confirm polygon designations, and are not intended to produce data for input into the LCCS.

3.2.3 Baseline (Pre-Disturbance) Evaluation

Baseline soils mapping is largely used to document soil distribution and type, and to guide soil conservation or material salvage for reclamation. It should provide information, in sufficient detail, on the types of soils present to support decision-making regarding optimum site location, materials handling, and post-disturbance soil reconstruction.

The project manager should determine the smallest area to be described and delineated in the field that can be read by users. The Expert Committee on Soil Survey (1987) recommends that minimum size delineation on a soil survey map is 1x1 cm. For linear features, this corresponds to 1 cm at a scale of 1:10 000.

SIL 1 is recommended for baseline footprints. For disturbances ≤10 ha, soil inspection densities are higher (see Table 4) to ensure adequate characterization of map units. For disturbances >10 ha, the minimum soil inspection density is 1/5 ha with a recommended minimum 3 sample sites per major soil series and 1 per minor soil series. A major soil unit is defined as one that occupies 3 % or more of the disturbance footprint (a minor unit occupying less than 3 % of the disturbance footprint). This can serve as a guide to ensure resources are properly allocated between dominant (major) and rare (minor) soil areas. Where sufficient foreknowledge or reference material are not available to differentiate between major and minor soil units, or if the surveyor perceives a soil has unique characteristics, it is recommended to sample at a higher intensity and reconcile the required analyses at the end of the project.

When soil series occupy >1 500 ha, sample one additional site per 500 ha increment. Unique sites or anomalies should have at least one sample site. In baseline mapping, the samples are required for characterization and classification and should be to a minimum 1 m depth. Where organic soils occur, determine the depth of the peat where >1 m. For SIL 2, only one sample site per unit is required, or adjacent SIL 1 data may be used if applicable.

3.2.4 Reclamation (Post-Disturbance) Evaluation

Sampling intensities are greater in post-disturbance applications, as outlined in Table 4. When materials are selectively handled, it is recommended that the soil inspection density be one per hectare and the soil sampling density be one per 10 ha, with a minimum of 2 per soil type. Soil type is considered the reclamation prescription (equivalent to a soil series). If better materials are not identified and selectively handled (nonselective handling), the recommended investigation and soil sampling densities are 4 per ha and one per 2 ha, respectively. The extents of unique sites or anomalies within the reclaimed landscape are to be defined by applying an intense grid (*i.e.*, step-out) of inspection sites around the anomaly for selective and non-selective handling.

Table 3. Criteria for identifying survey intensity levels[1].

Survey Intensity Level (SIL)	Common Name	Definitive Characteristics		Associated Features		
		Inspection Density	Investigations Methods	Main Kinds of Soil Components	Map Units[2]	Appropriate Publication Scale
SIL 1	very detailed	At least one inspection in every delineation (1 per 1 to 5 ha).	Transects or transverses less than 1 km apart. Profile descriptions and analyses for all soil series.	Series or phases of series.	Many simple units	1:10 000 (1:5 000 to 15 000)
SIL 2	detailed	At least one inspection in 90 % of the delineations (1 per 2 to 20 ha). Boundaries plotted by observations and interpretation of remotely sensed data verified at closely spaced intervals.	Transects and transverses 1.5 km or less apart. Profile descriptions and analyses for all major soil series.	Series or phases of series.	Simple and compound units.	1:20 000 (1:10 000 to 1:40 000)

[1] Adapted from Soil Mapping System for Canada: Revised (Expert Committee on Soil Survey, 1987).

[2] Simple units have over 80% of a single soil series or a non-limiting inclusion. Compound units are complexes or associations of two or more soil series.

Table 4. Guidelines for conducting soil surveys relative to development and reclamation.

Purpose	Level of Survey	Recommended Map Scale	Minimum Area Represented	Soil Inspection Density[d] (minimum) (1 m depth)	Soil Sampling Density[e] (minimum) (1 m depth, 3 principal horizons)
Mapping Land Areas					
			1 cm^2 on Map (ha)	Inspection/area	Sites
Baseline Footprint (<2 ha)	1	1:1 000	0.01	16/ha	1/major soil series
Baseline Footprint (2 – 10 ha)	1	1:5 000	0.25	8/ha	1/major soil series
Baseline Footprint (>10 ha)	1	1:10 000	1	1/5 ha	3/major soil series plus 1/500 ha 1/minor soil series
Baseline Buffer (Buffer = 500 m perimeter)	2	1:10 000	1	1/20 ha	1/major soil series plus 1/500 ha 1/minor soil series
Post-Disturbance (Nonselective Handling[a])	1	1:5 000	0.25	4/ha	1/2 ha 2/soil type
Post-Disturbance (Selective Handling[b])	1	1:10 000	1	1/ha	1/10 ha 2/soil type
Mapping Linear Corridors					
			1 cm on Map	Inspection/km	Sites/Major soil series
Baseline	1	1:10 000	200 m[c]	5	2
Post-Disturbance	1	1:10 000	200 m[c]	5	2

[a] Nonselective Handling = Soil materials excavated and replaced without selective handling; that is, without preferentially salvaging better materials.

b Selective Handling = Soil materials excavated, stored or transported, and replaced in a planned manner to salvage better quality materials. Areas of different materials, depths, and handling procedures are known, in accordance with reclamation plans.

[c] For similar map units, 200 m is minimum; for contrasting units, 20 m is the suggested minimum and/or a symbol notation may be used.

d Soil inspection density = an invasive (*i.e.*, hand-auger) inspection intended to evaluate variability within soil unit or type. Samples for analysis not required.

e Soil sampling density = an invasive (*i.e.*, soil pit) inspection where soil and landscape data and soil samples are collected to input into this land capability system.

Adapted from: Soil Quality Criteria Relative to Disturbance and Reclamation (Alberta Soils Advisory Committee, 1987).

3.3 Sampling Methods

Once the surface (2-dimensional) components of sampling (design and intensity) are defined, the next consideration is the vertical sampling design or protocol. Both natural and reclaimed soils vary significantly in degree of vertical stratification, having as few as one and as many as five or more recognizable horizons or strata. Vertical stratification in natural soils is a result of soil forming processes impacting parent material since time of deposition or exposure. Initial vertical stratification of reclaimed soils is anthropogenic in origin, and will be modified by soil forming processes over time.

Despite these differences, the intent of the LCCS is to compare natural and reclaimed land capability to assess equivalent capability, rendering the standardization of vertical sampling protocol between sites a critical exercise. The minimum number of vertical samples is three, representing the three LCCS principal horizons. Collection of three samples would occur where no material stratification is observed in the field (as in a homogenous 100 cm pedon) or where the pedon strata coincide with the LCCS principal horizons. Where more than three horizons or strata are identified and/or where they deviate from the LCCS principal horizons, additional samples are required.

At each sample site (see Section 3.2.2 for definition), soil horizons/strata are sampled discretely for the 1 m soil profile and the L, F and H horizons, where present. Samples are not to be composited between horizons or sample sites. Following is a list of good soil sampling practices.

- Samples should be collected from freshly dug pits or cuts. The pit should be 1 m deep, or to the bottom of the control section, whichever is deeper.
- Collect samples for analysis for the entire 1-m profile beginning from the bottom of the pit, from a face about 50 cm wide for laterally uniform soils.
- To ensure that samples are representative of the entire horizon or stratum, samples are to be collected from the entire interval, as opposed to the center of the interval. Sampling intervals should not overlap.

- If horizons are discontinuous, or vary greatly in thickness or degree of expression, collect samples from different locations on the pit face to ensure a representative sample of each horizon.
- Collect bulk density samples from the forest floor (L, F, and/or H layers should be sampled together) and all horizons or strata in the surface 20-cm mineral layer for mineral soils or the surface 20 cm for organic soils.
- Collect samples for chemical analysis from the forest floor (L, F, and/or H layers should be sampled together) and all horizons or strata within the 100-cm mineral or organic profile.

3.4 Analytical Requirements

Table 5 outlines the soil analyses required for input to the LCCS for land capability determination. Reference methods are from the Soil Quality Criteria Relative to Disturbance and Reclamation (Alberta Soil Advisory Committee, 1987) and Soil Sampling and Methods of Analysis (Carter, 1993). Additional analyses should be included as required by other program objectives.

Table 5. Required soil analyses by principal horizon for land capability determination for pre- and post-disturbance soils.

Parameter		Bulk Density[1]	Total Organic Carbon (TOC)[2]	Total Nitrogen (TN)[2]	Particle Size and Texture[3]	pH	EC, SAR
Method Reference[4]		Core method	Dry combustion	Kjeldahl	Particle size analysis	pH	Soluble cations in saturation extract
McKeague, 1978		Mineral (2.21) Organic (2.24)	(3.611)	(3.621 – 3.624)	Pipette (2.11) Hydrometer (2.12)	1:1 H_2O (3.12)	(3.21)
Carter, 1993		(50.2.1)	(21.4)	(22.2 – 22.3)	Pipette (47.2) Hydrometer (47.3)	1:2 H_2O (16.2)	(18.2.2)
Principal horizon	**Depth (cm)**	**Required (✓)**					
L,F,H	Variable	✓	✓	✓			
Topsoil[5] (TS)	0 - 20	✓	✓	✓	✓	✓	✓
Upper subsoil (US)	20 - 50				✓	✓	✓
Lower subsoil (LS)	50 - 100				✓	✓	✓

[1] Bulk density is required for the conversion of TOC and TN to Mg hectare^{-1}.

[2] The C:N ratio is calculated from TOC and TN. Percent organic matter (OM%) can be estimated from TOC% as follows: OM% = TOC% x 1.724.

[3] The pipette method (2.11) with pretreatment to remove organics is most appropriate for soils with >2% TOC.

[4] Numbers in parentheses refer to corresponding sections in cited reference manuals.

[5] Any and all horizons beginning between 0 and 20 cm in the soil profile are considered TS horizons and require nutrient and bulk density analysis.

3.5 Landscape and Soil Features

This section lists the key landscape and soil features that must be collected from each sample site for input into the LCCS. A field form is included as Appendix C.

The Canada Soil Information System (CanSIS): Manual for Describing Soils in the Field (Working Group on Soil Survey Data, 1983) presents standards for describing the individual parameters outlined below. *The Canadian System of Soil Classification* (Soil Classification Working Group, 1998) is used for the soil classification of natural soils.

3.5.1 Site Description

A site description normally includes the following (CanSIS section in parenthesis):

- site type (natural or reclaimed)
- parent material (8A),
- landform classification (8B),
- slope (percent, type, class, aspect, position and length) (8C),
- soil moisture regime and drainage (class, seepage, water table) (8D),
- stoniness (surface stoniness) (8J),
- present land use (as related to delineated soil types) (8L).

3.5.2 Soil Profile Description

The following list of morphological characteristics of the soil profile must be recorded for input to the LCCS (CanSIS section in parenthesis). Additional guidance for some parameters is presented in the following subsections.

- horizon designation (CSSC, 10A, Section 3.5.2.1, Appendix B),
- horizon depth and thickness (10B, Section 3.5.2.2),
- color (10C),
- texture (10K),
- structure (grade, class, kind) (10M),

- consistence (aggregate strength) (10N),
- mottles (10L);
- depth to water table (cm) (8G1);
- roots (depth, abundance, orientation, distribution) (10T),
- $CaCO_3$ effervescence (10W2);
- percent volume coarse fragments (≥2 mm diameter) by horizon
- water permeability (Section 3.5.2.3)

3.5.2.1 Horizon Designations

For natural soils, standard horizon designations as outlined in the CSSC (Soil Classification Working Group, 1998) are to be used for soil profile descriptions.

Currently, no comprehensive standardized list exists for horizon designations of reclaimed soils. The LCCS principal horizons (TS, US, and LS) are not to be used as horizon designations for describing reclaimed soils because they imply a defined depth range.

The horizon designations of organic-enriched strata (*i.e.*, peat mineral mixes) are to be "Ptmix", and tailings sand, "TSS". Otherwise, the horizon designations for reclaimed soils are user defined. Suggested horizon designations are presented in Appendix B.

3.5.2.2 Horizon Depth and Thickness

Horizon depth is to be recorded in two separate fields as the upper and lower limits of each horizon from which the horizon thickness can be calculated.

3.5.2.3 Water Permeability

As part of the soil moisture regime (SMR) determination, it is necessary to identify whether soil horizons are permeable to water. Water-impermeable layers perch water in the overlying material but have zero water storage potential and must be identified to account for these characteristics.

It is not expected that the SMR determination be made quantitatively, although quantitative measures can be used to support the determination. Based on the surveyor's observations and

knowledge, each layer or strata is to be identified as either permeable or impermeable to water. Some examples of potentially impermeable layers include un-fractured bedrock (R), un-weathered Cretaceous Clearwater overburden (KC), and oil sand (Cretaceous McMurray overburden, "KM").

4.0 LAND CAPABILITY RATING

Using collected data and this manual, the land capability rating is calculated for soil sample sites using The Land Capability Worksheet (Appendix D). The procedure for determining a land capability rating is summarized in Section 4.1 and details are presented in the subsequent sections. Full disclosure to and acceptance by regulatory agencies is required for any deviation(s) from the procedure outlined in this document.

There may be cases where ratings produced by this land capability system conflict with vegetative indicators of edaphic conditions. On natural sites, where the relationship between vegetation and edaphic conditions are relatively well understood, presence or absence of vegetation indicator species may provide a more reliable assessment of capability than the LCCS. In such cases, the project manager may wish to propose an altered LCCS rating. Both the unaltered and proposed altered ratings will be submitted to Alberta Environment, Alberta Sustainable Resource Development, and the SVSG, along with site data and rationale for proposed alteration, for comment, review, and approval (the latter by the regulatory agencies). A collection of such information will be very helpful in developing the next edition of the classification system.

4.1 Land Capability Rating Determination Overview

The following is an overview of the land capability rating process as illustrated in Figure 2.

I. Determine SMR index, as follows:

- Where the depth to water table is ≤100 cm, SMR index and subclass is determined by the soil subgroup classification, as defined by the CSSC (Soil Classification Working Group, 1998);
- Where the depth to water table is >100 cm, SMR index and subclass is determined by AWHC in the 0-100 cm profile, as inferred from texture (particle size analysis) and coarse fragments (percent volume), and excluding surface organic matter and impermeable layers; and
- Adjust SMR for soil layering and slope effect modifiers, if applicable.

II. Determine SNR index from total organic carbon, total nitrogen, and C:N ratio of the L, F, H, and TS (0-20 cm) layers in mineral soils or surface 20 cm of organic soils; and the fine-fraction texture of the TS and US layers.

III. Determine the Base Rating (the sum of the SMR and SNR indices);

IV. Examine the soil profile to determine the extent of potentially limiting physical and chemical features of the principal soil horizons (soil structure and consistence, pH, EC, and SAR). Calculate deductions as specified by the worksheet (Appendix D) and calculate the Final Land Rating;

V. Use final land rating to place soil profile into soil capability class. Assign subclasses by either the general or detailed approach (Section 2.3.1).

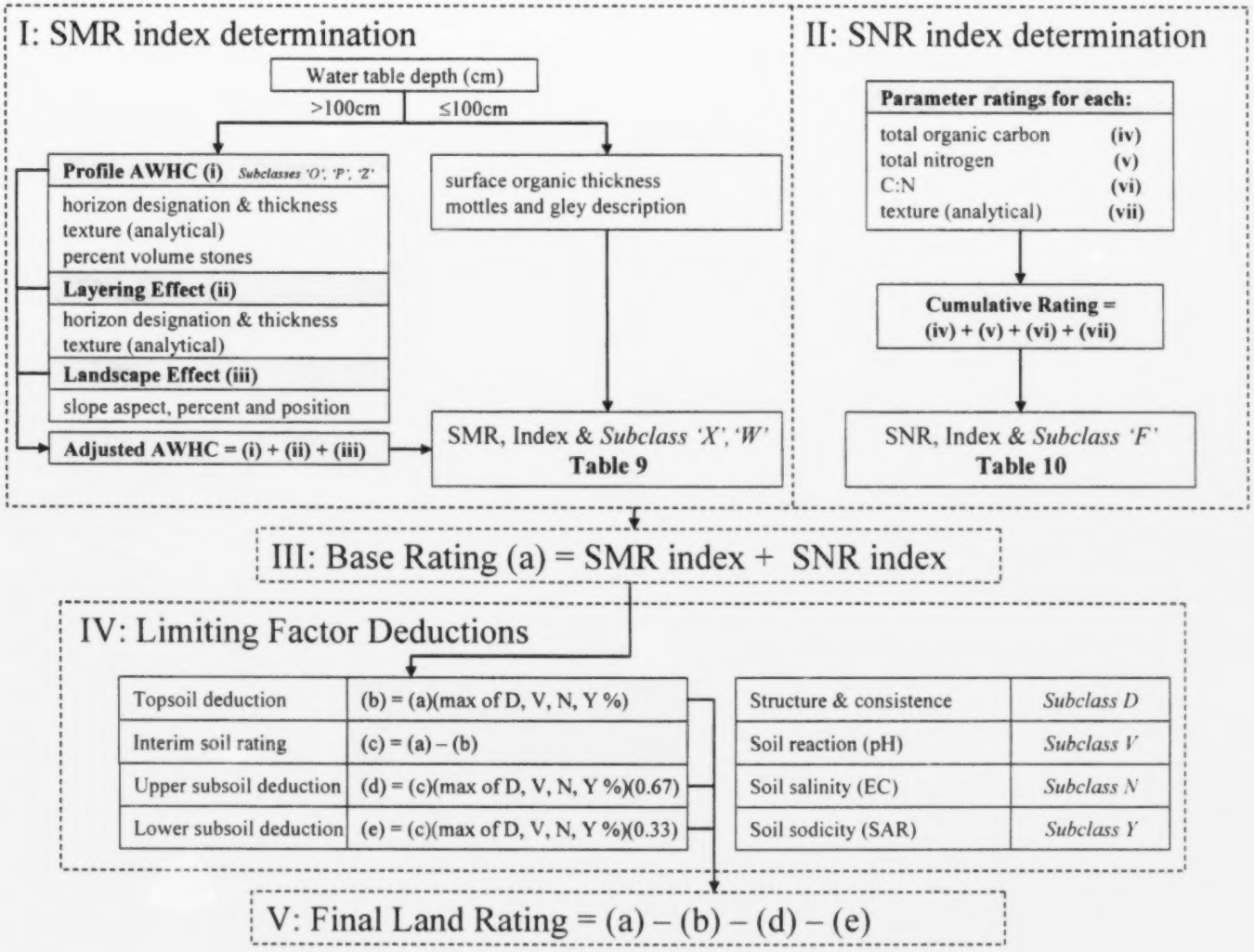

I: SMR index determination
Water table depth (cm)
>100cm
≤100cm
Profile AWHC (i) Subclasses 'O', 'P', 'Z'
horizon designation & thickness
texture (analytical)
percent volume stones
Layering Effect (ii)
horizon designation & thickness
texture (analytical)
Landscape Effect (iii)
slope aspect, percent and position
Adjusted AWHC = (i) + (ii) + (iii)
surface organic thickness
mottles and gley description
SMR, Index & Subclass 'X', 'W'
Table 9
II: SNR index determination
Parameter ratings for each:
total organic carbon (iv)
total nitrogen (v)
C:N (vi)
texture (analytical) (vii)
Cumulative Rating =
(iv) + (v) + (vi) + (vii)
SNR, Index & Subclass 'F'
Table 10
III: Base Rating (a) = SMR index + SNR index
IV: Limiting Factor Deductions
Topsoil deduction (b) = (a)(max of D, V, N, Y %)
Interim soil rating (c) = (a) – (b)
Upper subsoil deduction (d) = (c)(max of D, V, N, Y %)(0.67)
Lower subsoil deduction (e) = (c)(max of D, V, N, Y %)(0.33)
Structure & consistence Subclass D
Soil reaction (pH) Subclass V
Soil salinity (EC) Subclass N
Soil sodicity (SAR) Subclass Y
V: Final Land Rating = (a) – (b) – (d) – (e)

Figure 2. Schematic diagram of land capability rating process.

4.2 Soil Moisture Regime (SMR) Index: Subclass W or X

Land capability rating begins with the determination of the soil moisture regime (SMR) index as outlined in the Land Capability Worksheet (Appendix D) and as follows:

- Where seepage and water table are >100 cm below surface (moisture regime mesic or drier), the profile AWHC (mm 100 cm^{-1}) is inferred from texture using Table 6 and subsequently adjusted by a series of modifiers to determine the *adjusted AWHC* (Section 4.2.1) which determines the SMR index using Table 9.
- Where water table is present within 100 cm of surface (moisture regime subhygric or wetter), depth to the water table, surface organic thickness, and mottle/gley description determines the SMR index using Table 9 (the calculation of profile AWHC is not necessary). Proceed to Section 4.2.2 and Table 9.

4.2.1 SMR Index Determination Where Water Table >100 cm

4.2.1.1 Profile AWHC

For mesic or drier sites (where water table is below 100 cm of soil surface), the SMR index is determined in a stepwise manner. First, profile AWHC is inferred from texture and horizonation, or layering, of mineral soil horizons or layers.

The L, F, and H surface organic horizons of natural and reclaimed soils are not included in the calculation of profile AWHC (recall from Figure 1 that these layers are above the LCCS principal horizons for both natural and reclaimed soils).

In reclaimed soils where a surface organic-enriched stratum contains greater than 17% TOC, this stratum does not contribute to the profile AWHC. However, where overlain by sufficient mineral material, organic layers can contribute to the profile AWHC (refer to Section 4.2.1.1.1, "Organic modifier – Subclass O").

For the underlying materials, a multiplier (mm water per cm of soil) is applied to each qualifying horizon to the maximum 1 m profile depth. Qualifying horizons are those that are permeable to water and above any impermeable layer (*i.e.*, horizons beneath an impermeable layer do not contribute to the profile AWHC) (refer to Section 4.2.1.1.3, "Impermeable layer modifier – Subclass Z").

The effective AWHC of any horizon or strata must be reduced proportionately to the percent volume of that strata occupied by coarse fragments, where that volume is at least 10 % (refer to Section 4.2.1.1.2, "Stoniness modifier – Subclass P").

Profile AWHC is determined by summing the AWHC (mm) for each soil layer in the 1 m soil profile. Multipliers for the range of soil textures and horizon designations are presented in Table 6.

Table 6. Available water holding capacity multipliers (mm cm^{-1}) by texture for natural and reclaimed soils.

Field Capacity Soil Suction	Description			Texture class †	Horizon designation	mm/cm
n/a	Organic material (>17 % TOC)	Surface	Natural	n/a	O	0.0
			Reclaimed	n/a	-	0.0
		Buried	Reclaimed	n/a	-	1.0
-10 kPa[1]	Peat: mineral mix‡			LS, S	Ptmix	1.2
				SL or finer	Ptmix	1.7
	Tailings sand (typically LS or S)				TSS	1.0
	Sand			S	-	0.8
	Loamy sand			LS	-	1.1
	Sandy loam			SL	-	1.4
-33 kPa	Loam, sandy clay, sandy clay loam			L, SC, SCL	-	1.5
	Clay loam			CL	-	1.7
	Silty loam, silt, silty sand			SiL, Si, SiS	-	1.8
	Clay, silty clay loam, silty clay			C, SiCL, SiC	-	1.6

† **Symbols:** L = loam, S = sand, Si = silt, C = clay.

Horizon designations: O = organic (>17% total organic carbon).

Ptmix = a mineral reclaimed horizon that is enriched in organic material. The texture of the mineral component (as obtained analytically) determines the multiplier for Ptmix..

TSS = tailings sand. The horizon designation determines the multiplier regardless of texture (the texture should be S or SL).

‡ Peat: mineral mixes 1:1 to 1:4 (volume) mix or more peat (Moskal, 1999).

The applicable AWHC multiplier for most horizons or layers is determined by the soil texture, as determined by the methods outlined in Section 3.4. As shown in Table 6, the multipliers for some horizons or layers are dependent on the horizon designation assigned to that layer.

Texture-determined multipliers: For mineral materials (≤ 17% TOC) that permit water transmission (*i.e.*, are not water repellent/impermeable), the soil texture determines the multiplier, ranging from 0.8 mm cm^{-1} for sand (S) to 1.8 mm cm^{-1} for silty loam (SiL), silt (Si)

and silty sand (SiS) (Table 6). Example 1 shows a profile AWHC calculation for a natural mineral soil profile where only texture-determined multipliers are used.

Example 1. Profile AWHC for a natural mineral soil profile with no limitations.

Horizon Designation	Texture	Horizon Thickness	Multiplier	AWHC	% Coarse Fragments Adjustment		AWHC
		(cm)		(mm)	(vol.)	(mm)	(mm)
L,F	-	6	-	-	-	-	-
Ae	S	20	0.8	16	0	0	16
Bm	LS	30	1.1	33	0	0	33
BC	LS	50	1.1	55	0	0	55
						Profile AWHC = Σ	104 (i)

Horizon designation-determined multipliers: For some materials or horizons, the horizon designation, not the soil texture, determines the multiplier. These include natural organic horizons (with an "O" master horizon designation), tailings sand (TSS), and peat/mineral mixes (Ptmix) (Table 6).

All soil horizons or strata will be classified as either mineral or organic based on total organic carbon (TOC %) data where available. Natural organic soil horizons or layers (with master horizon designation of O) are assumed to be organic. Organic soil horizons or strata will be assigned a multiplier of 0 mm cm^{-1}.

All other horizons are assumed to be mineral horizons and are assigned multipliers based on texture class as outlined in Table 6.

In the field, the horizon designation for "Ptmix" is applied to reclaimed soil layers where peat was mixed with mineral material (typically surface layers). The multiplier is determined by the texture of the mineral component (refer to Section 3.4).

A multiplier of 1.0 mm cm^{-1} is applied to any horizon with the TSS (tailings sand) horizon designation, regardless of texture.

The following sections provide example AWHC calculations for a range of examples: organic layers, layers with > 10% coarse fragments, and impermeable layers.

4.2.1.1.1 Organic modifier – Subclass O

Organic soils (peat) are salvaged for use in reclamation. Typically, peat is mixed with underlying mineral material at either the material salvage stage by over-stripping peat deposits or

post-placement by mechanical incorporation. These peat/mineral mixes are usually classed as mineral soils (≤ 17 % TOC). However, due to numerous factors, homogeneity of material is difficult to achieve and organic material (>17 % TOC) can occur in the reclaimed soil profile.

4.2.1.1.1.1 Surface organic

For reclaimed soils, where the TOC content of surface material is > 17 %, the layer or strata is considered a component of the profile (recall Figure 1) but **does not** contribute to the profile AWHC and is assigned a multiplier of 0.0 mm cm^{-1}. A reduction in profile AWHC is incurred for each centimeter of organic material if it occurs/begins within the top 10 cm of the soil surface and the subclass "O" is applied where peaty surface horizon is ≥15 cm thick. The underlying mineral material **does** contribute to the profile AWHC. Subclass "O" would be applied to the 20 cm-thick organic horizon in the reclaimed soil in Example 2.

Example 2. Profile AWHC for a reclaimed profile with surface organic material.

Horizon Designation	Texture	Horizon Thickness	Multiplier	AWHC	% Coarse Fragments Adjustment		AWHC
		(cm)		(mm)	(vol.)	(mm)	(mm)
Ptmix†	-	20	0.0	0	0	0	0
MIN	CL	30	1.7	51	0	0	51
TSS†	S	50	1.0	50	0	0	50
						Profile AWHC = Σ	101 (i)

† Note that although this layer was defined as a "Ptmix" in the field, the analytical results returned >17% TOC, therefore a multiplier of 0 is applied.

4.2.1.1.1.2 Buried organic

In reclaimed soils where organic material occurs beneath a minimum of 10 cm mineral material, the organic material **does** contribute to the profile AWHC and is assigned a conservative multiplier of 1.0 mm cm^{-1}. Subclass "O" does not apply to buried organic horizons. An example is presented in Example 3. It should be noted that the "buried organic" AWHC multiplier has been developed to address isolated occurrences on reclaimed landscapes. This practice is not recommended as a standard reclamation technique prior to evaluation of its performance in the field.

Example 3. Profile AWHC for a reclaimed profile with buried organic material.

Horizon Designation	Texture	Horizon Thickness	Multiplier	AWHC	% Coarse Fragments Adjustment		AWHC
		(cm)		(mm)	(vol.)	(mm)	(mm)
MIN†	CL	30	1.7	51	0	0	51
Ptmix	-	20	1.0	20	0	0	20
TSS	S	50	1.0	50	0	0	50
						Profile AWHC = Σ	121 (i)

† Note that the texture of the layer determines the multiplier.

4.2.1.1.2 Stoniness modifier – Subclass P

Percent volume of coarse fragments (mineral material >2 mm diameter) data is collected by horizon to the nearest 10 %. The presence of coarse fragments reduces the effective soil volume available for water storage. For any horizon containing 10 % or more coarse fragments, the horizon AWHC is reduced proportionately, as illustrated by Example 4. Where the total adjustment for a profile is ≥ 30 mm, Subclass "P" is applied. In Example 4, 10 % coarse fragments in the peat mix (Ptmix) and 30 % coarse fragments in the mineral layer (MIN) resulted in a 17.7 mm loss therefore the "P" subclass notation would not be applied.

Example 4. Profile AWHC for a reclaimed mineral profile with coarse fragments.

Horizon Designation	Texture	Horizon Thickness	Multiplier	AWHC	% Coarse Fragments Adjustment		AWHC
		(cm)		(mm)	(vol.)	(mm)	(mm)
Ptmix†	S	20	1.2	24	10	2.4	21.6
MIN	CL	30	1.7	51	30	15.3	35.7
TSS‡	S	50	1.0	50	0	0	50
						Profile AWHC = Σ	107.3 (i)

† Note that the horizon designation coupled with the texture determines the multiplier.

‡ Note that the horizon designation determines the multiplier, not the texture for the TSS.

4.2.1.1.3 Impermeable layer modifier – Subclass Z

Where impermeable or water-repellent layers are present within the 1-m profile, regardless of their soil texture class, these materials **do not** contribute to the profile AWHC and are assigned a multiplier of 0.0 mm cm^{-1}. Impermeable layers are identified qualitatively as described in Section 3.5.2.3.

The profile contributing to the AWHC is limited to the material above the impermeable layer. Subclass "Z" is applied where an impermeable layer reduces the effective profile by at least 30 cm, *i.e.*, where it occurs within 70 cm of the soil surface. In Example 5, a KC water-repellent layer beginning at 50 cm in the mineral profile causes the "Z" subclass to be applied.

Example 5. Profile AWHC for mineral profile with an impermeable layer.

Horizon Designation		Texture	Horizon Thickness (cm)	Multiplier	AWHC (mm)	% Coarse Fragments Adjustment (vol.)	(mm)	AWHC (mm)
Ptmix†		S	20	1.2	24	0	0	24
MIN		CL	30	1.7	51	0	0	51
KC‡	*	SL	50	0.0	0	0	0	0
							Profile AWHC = Σ	75 (i)

* Denotes an impermeable layer.

† Note that the horizon designation coupled with the texture determines the multiplier.

‡ Note that this KC layer is impermeable and therefore a multiplier of 0 is applied.

In Example 6, the water-repellent layer occupies only 30 cm of the profile, but reduces the effective profile to 20 cm. The underlying mineral material does not contribute the profile AWHC.

Example 6. Where impermeable layer occurs within the profile, any underlying material does not contribute to the AWHC.

Horizon Designation		Texture	Horizon Thickness (cm)	Multiplier	AWHC (mm)	% Coarse Fragments Adjustment (vol.)	(mm)	AWHC (mm)
Ptmix		S	20	1.2	24	0	0	24
KC†	*	SL	30	0.0	0	0	0	0
MIN‡		CL	50	0.0	0	0	0	0
							Profile AWHC = Σ	24 (i)

* Denotes an impermeable layer.

† Note that this KC layer is impermeable and therefore a multiplier of 0 is applied.

‡ Note that a multiplier of 0 is applied to this permeable layer because it underlies an impermeable layer.

4.2.1.2 Layering Modifiers

Recent soil moisture research in reclaimed systems and extensive field experience in natural systems of the region indicate that soil layering (textural/lithological discontinuities) can influence the soil moisture regime.

The three following layering modifiers were developed to account for observations of wetter soil conditions on natural sites than those indicated by calculated profile AWHC (information from the Soil and Vegetation Plots), and for documented increases in total AWHC in several layered, reclaimed systems (O'Kane, 2003; and Chaikowsky, 2003).

Horizons of differing texture must be described and sampled discretely for layering modifiers to be applied. Two adjacent horizons or strata must have unique horizon designations. Where soils meet the criteria outlined below (summarized in Table 7), the profile AWHC is increased by 15 mm of AWHC (approximately one half class equivalent). The total maximum upgrade is 15 mm (two layering multipliers cannot be applied to a single site).

4.2.1.2.1 Impermeable subsoil

In *natural or reclaimed* soils where there is a water-repellent layer (recall R, KC, IMP, i) in the lower subsoil (50 - 100 cm), upgrade submesic or drier moisture regimes (≤145 mm profile AWHC before adjustment, Table 9) by 15 mm AWHC for lower, toe, depression, and level slope positions (Figure 3) (O'Kane, 2003). Application of this modifier is illustrated in Example 7.

Example 7. Profile AWHC for a natural mineral soil with a shallow bedrock.

Horizon Designation	Texture	Horizon Thickness	Multiplier	AWHC	% Coarse Fragments Adjustment			AWHC	
		(cm)		(mm)	(vol.)	(mm)		(mm)	
Ah	LS	8	1.1	8.8	0	0		8.8	
Ck	LS	46	1.1	50.6	0	0		50.6	
R	-	46	0.0	0	0	0		0	
						Profile AWHC =	Σ	59.4	(i)
						Impermeable subsoil	✓	15	
						Coarse over fine material stratification	×		
						Fine over coarse material stratification	×		
						Layering effect =		15	(ii)
						Adjusted AWHC =		74.4	

4.2.1.2.2 Coarse over fine material stratification

In sand or loamy sand *natural* soils where there is a textural discontinuity (material with ≥30 % clay) at least 10 cm in thickness in the lower subsoil (50 - 100 cm), upgrade submesic or drier moisture regimes (≤145 mm profile AWHC before adjustment) by 15 mm AWHC for lower, toe, depression, and level slope positions (Figure 3) (O'Kane, 2003). (Example: a sandy veneer overlying fine-textured morainal deposits [Example 8]).

Example 8. Profile AWHC for a natural mineral soil with coarse over fine material stratification in the subsoil.

Horizon Designation	Texture	Horizon Thickness (cm)	Multiplier	AWHC (mm)	% Coarse Fragments Adjustment (vol.)	(mm)	AWHC (mm)	
LF	-	5	0.0	0	0	0	0	
Ah	LS	5	1.4	7	0	0	7	
Ae	S	10	0.8	8	0	0	8	
Bm	LS	30	1.4	42	0	0	42	
C	LS	10	1.4	14	0	0	14	
IICk	C	45	1.6	72	0	0	72	
						Profile AWHC =	Σ 143	(i)
						Impermeable subsoil	×	
						Coarse over fine material stratification	✓ 15	
						Fine over coarse material stratification	×	
						Layering effect =	15	(ii)
						Adjusted AWHC =	158	

4.2.1.2.3 Fine over coarse material stratification

In layered *natural and reclaimed* soils where there is fine material (≥30 % clay) over coarse material (S, LS, SL) in the lower subsoil (50 - 100 cm), upgrade submesic or drier moisture regimes (≤145 mm profile AWHC before adjustment) by 15 mm AWHC for lower, toe, depression, and level slope positions (Figure 3) (Moskal, 1999; O'Kane, 2003; Chaikowsky, 2003).

Examples include Ruth Lake soils (natural) and tailings sand reclamation with fine-textured mineral material as a component of the soil cap (Example 9).

Example 9. Profile AWHC for a reclaimed mineral soil with fine over coarse material stratification in the subsoil.

Horizon Designation	Texture	Horizon Thickness (cm)	Multiplier	AWHC (mm)	% Coarse Fragments Adjustment (vol.)	(mm)	AWHC (mm)
Ptmix	S	25	1.2	30	0	0	30
MIN	CL	30	1.7	51	0	0	51
TSS	S	45	1.0	45	0	0	45

Profile AWHC =	Σ	126	(i)
Impermeable subsoil	×		
Coarse over fine material stratification	×		
Fine over coarse material stratification	✓	15	
Layering effect =		15	(ii)
Adjusted AWHC =		141	

Table 7. Summary of boundary conditions for the application of layering modifiers[1].

Boundary Conditions	Layering Modifier		
	Impermeable subsoil Natural and reclaimed	**Coarse/Fine** Natural only	**Fine/Coarse** Natural and reclaimed
Initial SMR	Submesic or drier ≤145 mm 100 cm^{-2} profile AWHC prior to adjustment		
Texture of overlying layer	No limitations	S, LS	≥ 30% clay
Texture of underlying layer	Water impermeable[1]	≥ 30% clay	S, LS
Minimum thickness fine strata	none	10 cm	none
Depth at which boundary must occur	50-100 cm	50-100 cm	50-100 cm
Landscape boundaries	Receiving positions only[3]	Receiving positions only[3]	Receiving positions only[3]
Upgrade	**15 mm**	**15 mm**	**15 mm**

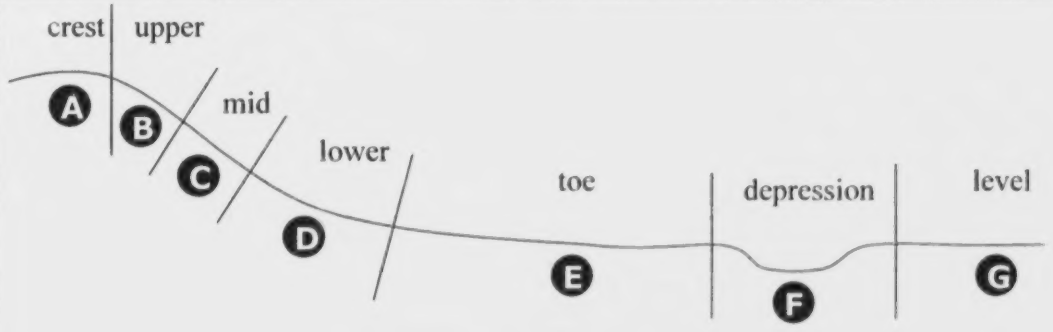
[1] Note: all applicable criteria within the appropriate layering modifier column must be met in order for that modifier to be applied.

[2] Layer identified as impermeable (See Section 3.5.2.3).

[3] For lower, toe, depressional, and level positions, as illustrated in Figure 3.

4.2.1.3 Landscape Modifier

Slope steepness, aspect, and position are considered in terms of influencing potential droughtiness or wetness. Slope steepness is recorded in percent (%) ranging from 0 to 100 %. Aspect is the direction toward which the surface of the soil faces, expressed as an angle between 0 and 360 degrees true measured clockwise from true north. Slope position is the location of the sample site within the segment of the slope, recorded as crest, upper slope, mid slope, lower slope, toe, depression or level (see Figure 3). Slope length and type (complex versus simple) and microtopography are not considered in the LCCS at this time.



A	Crest	The uppermost portion of a slope; shape usually convex in all directions with no distinct aspect.
B	Upper slope	The upper portion of the slope immediately below the crest; slope shape usually convex with a specific aspect.
C	Mid slope	The area of the slope between the upper and the lower slope where the slope shape is usually planar with a specific aspect.
D	Lower slope	The lower portion of the slope immediately above the toe; slope shape usually concave with a specific aspect.
E	Toe	The lowermost portion of the slope immediately below or adjacent to the lower slope; slope shape concave grading rapidly to level with no distinct aspect.
F	Depression	Any area that is concave in all directions, usually at the toe of the slope or within level topography.
G	Level	Any level area excluding toe slopes, generally horizontal with no distinct aspect.

Figure 3. Slope positions and corresponding characteristics.

For submesic or drier moisture regimes (<145 mm profile AWHC before adjustment) with slope ≥10 % make adjustments (deductions or additions) as shown in Table 8.

Table 8. Landscape adjustments according to aspect and slope position for slopes ≥10 %.

Aspect (degree range, true)	Slope Position						
	Crest	Upper	Mid	Lower	Toe	Depression	Level
	A	B	C	D	E	F	G
NW-NE (316-45)	-15	0	+15	+15	0	0	0
NE-SE (46-135)	-15	-15	0	0	0	0	0
SE-SW (136-225)	-15	-30	-30	-30	0	0	0
SW-NW (226-315)	-15	-15	0	0	0	0	0

4.2.1.4 Adjusted AWHC (water table >100 cm)

The *profile AWHC* has the potential to be increased by the layering effect and increased or decreased by the landscape effect. The *adjusted AWHC* is used with Table 9 to determine the SMR index for sites where the water table is below 100 cm.

Equation 2. Adjusted AWHC.

Adjusted AWHC = profile AWHC + layering effect + landscape effect

To assign the SMR index, locate the *adjusted AWHC* in the AWHC (mm 100 cm^{-1} profile) column of Table 9 and apply the corresponding SMR index and subclass.

4.2.2 SMR Index Determination Where Water Table ≤100 cm

4.2.2.1 Natural Soils

For subhygric or wetter sites (where water table is within 100 cm of soil surface), the SMR index is determined by guidelines presented in Table 9 for water table depth, mottle/gley descriptions, surface organic thickness, and other factors (*e.g.*, tree growth performance), as determined by the soil surveyor. Mottles are described according to the CanSIS manual (Working Group on Soil Survey Data, 1983).

There may be cases in natural organic soils (organic horizons ≥40 cm) where the depth to water table will be greater than 100 cm. In these cases, SMR should be determined based on

descriptive criteria in Table 9, not on AWHC calculations in Table 6, as these soils are not likely to have a mesic or drier moisture regime.

4.2.2.2 Reclaimed Soils

At this time, reclaimed soils have had insufficient time to develop critical indicators (mottling, surface organic development, and tree growth and performance) required for the identification of subhygric and hygric aerated moisture regimes. Therefore, the SMR index for reclaimed soils with water tables within 100 cm of the soil surface is determined solely by the depth to that water table (Table 9). Reclaimed soils with water tables between 30 and 100 cm from the soil surface are limited to "Hygric reduced" (7r).

Table 9. Guide to determining soil moisture regime.

Moisture Regime	Description	Idealized Slope Position[1]	Surface Organic Thickness (cm)	Water Table Depth (cm)	Primary Water Source	Common Texture[2]	Soil Drainage Class	Common Ecosites[3]	Adjusted AWHC[4] (mm 100 cm)	SMR Index and Subclass
Very xeric (1)	Water removed extremely rapidly in relation to supply; soil is moist for a negligible time following precipitation.	A – B All	< 3	>100	Precipitation	Very coarse (gravel – S) Shallow soil	Very rapid	n/a	<56[5] (40)	10X
Xeric (2)	Water removed very rapidly in relation to supply; soil is moist for brief periods following precipitation.	A – B All	< 3	>100	Precipitation	Coarse (S)	Very rapid to rapid	a	56 – 85 (70)	24X
Subxeric (3)	Water remover rapidly in relation to supply; soil is moist for short periods following precipitation.	B – C Variable	< 3	>100	Precipitation	Coarse to moderately coarse (LS – SL)	Rapid	a, b	86 – 115 (100)	38X
Submesic (4)	Water removed readily in relation to supply; water available for moderately short periods following precipitation.	B – C Variable	3 – 5	>100	Precipitation	Moderately coarse (SL)	Rapid to well	b, c, d	116 – 145 (130)	52
Mesic (5)	Water removed somewhat slowly in relation to supply; soil may remain moist for significant but sometimes short periods of the year; available soil water reflects climatic inputs.	C Variable	6 – 9	>100	Precipitation in moderate to fine-textured soil and limited seepage in coarse-textured soils	Medium (SiL – L) to fine (SCL – C) Few coarse fragments	Well to moderately well	c, d	146 – 175 (160)	66
Subhygric (6)[6]	Water removed slowly enough to keep the soil wet for a significant part of the growing season; some temporary seepage and possible mottling below 20 cm.	D Variable	10 – 40	May be < 100	Precipitation and seepage	Variable depending on seepage	Imperfect	e, g	Equivalent to > 175 (190)	80
Hygric (7a)[6]	Hygric aerated: Water removed slowly enough to keep the soil wet for most of the growing season; mottling present within 50 cm.	E – G	16 – 40	30-100	Permanent seepage; water table fluctuates often <100 cm	Variable depending on seepage	Poor	g, h, f	Wet	66
Hygric (7r)	Hygric reduced: Water removed slowly enough to keep the soil wet for most of the growing season; >50% gley within 50 cm.	E – G	16 – 40	30-100	Seepage; water table fluctuates often <100 cm	Variable depending on seepage	Poor	g, h, f	Wet	24W

Moisture Regime	Description	Idealized Slope Position[1]	Surface Organic Thickness (cm)	Water Table Depth (cm)	Primary Water Source	Common Texture[2]	Soil Drainage Class	Common Ecosites[3]	Adjusted AWHC[4] (mm 100 cm)	SMR Index and Subclass
Subhydric (8)	Water removed slowly enough to keep the water table at or near surface for most of the year; organic and gleyed mineral soils; permanent seepage < 30 cm below soil surface.	E – G	> 40	0-30	Seepage or permanent water table <30 cm	Variable depending on seepage	Very poor	i, j, k	Wet	0W
Hydric (9)	Water removed so slowly that the water table is at or above the soil surface all year; organic and gleyed mineral soils.	E – G	> 40	0	Permanent surface water table	Variable depending on seepage	Very poor	l	Wet	0W

[1] See Figure 3 - Idealized slope positions do not take into account potentially significant scale effects; in cases of conflict between this and other indicators (such as common texture and vegetation), the other indicators should be taken as paramount.

[2] L = loam, S = sand, Si = silt, C = clay.

[3] As defined by Beckingham and Archibald (1996).

[4] As determined from profile AWHC, layering modifiers and slope modifiers.

[5] Range (mode) (information from the Soil and Vegetation Plots)

[6] Subhygric and hygric aerated moisture reqimes are to be applied only to natural soils.

4.3 Soil Nutrient Regime (SNR) Index: Subclass F

The soil nutrient regime (SNR) index is based on the total organic carbon (Mg ha^{-1}); total nitrogen (Mg ha^{-1}); C:N ratio of the L, F, and H horizons (where present); *plus* the TS (0-20 cm) and the percent sand in the TS and US principal horizons.

4.3.1 Total Organic Carbon and Total Nitrogen

The total organic carbon (TOC; Mg ha^{-1}) is determined from the percent organic carbon and bulk density data for the L, F, and H horizons *plus* TS (Example 10). The total nitrogen (Mg ha^{-1}) is determined from the percent total nitrogen and bulk density data (Example 11).

Example 10. Calculating TOC (Mg ha^{-1}) for a 0.20 m-thick topsoil horizon with a bulk density of 1.0 Mg m^{-3} and a TOC content of 4.0%.

$$TOC\ \ Mg\ C\ ha^{-1} = \left(\frac{4\ Mg\ C}{100\ Mg\ soil}\right) x \left(\frac{1\ Mg\ soil}{m^3}\right) x \left(\frac{0.20\ m\ soil}{}\right) x \left(\frac{10000 m^2}{ha}\right) = 80\ Mg\ \ C\ \ ha^{-1}$$

Example 11. Calculating total nitrogen (Mg ha^{-1}) for a 0.20 m-thick topsoil horizon with a bulk density of 1.0 Mg m^{-3} and a total nitrogen content of 0.20%.

$$\text{Total nitrogen}\ \ Mg\ \text{N}\ ha^{-1} = \left(\frac{0.2\ Mg\ \text{N}}{100\ Mg\ \text{soil}}\right) x \left(\frac{1\ Mg\ \text{soil}}{m^3}\right) x \left(\frac{0.20\ m\ \text{soil}}{}\right) x \left(\frac{10000 m^2}{ha}\right) = 4\ Mg\ \text{N}\ ha^{-1}$$

4.3.2 C:N Ratio

The TOC and total nitrogen are determined for each horizon and summed across these horizons. The carbon to nitrogen ratio (C:N) is determined from the TOC and total nitrogen data for the L,F and H *plus* TS (0-20 cm) as illustrated in Example 12.

Example 12. Calculating C:N ratio for the topsoil *plus* L,F and H horizons of a soil with TOC of 52.6 Mg ha^{-1} and total nitrogen of 3.4 Mg ha^{-1}.

Horizon Designation	Depth (cm)	Horizon Thickness (cm)	Bulk Density (Mg m^{-3})	TOC (%)	TOC (Mg ha^{-1})	Total Nitrogen (%)	Total Nitrogen (Mg ha^{-1})
LF	5-0	5	0.2	17	**17**	2	**2**
Ae	0-10	10	1.1	3	**33**	0.1	**1.1**
Bm	10-20*	10	1.3	0.2	**2.6**	0.02	**0.3**
					Σ **52.6**		Σ **3.4**
					C:N = 52.6 / 3.4 = 15		

4.3.3 Nutrient Retention Factor

A soil texture component is used to capture the importance of nutrient retention ability of finer-textured mineral materials. The points for topsoil and upper subsoil textures are based on increasing clay content, progressing from sand to finer materials, and associated cation exchange capacity for retaining nutrients in the absence of organic matter. Organic horizons (O horizons) are assigned a zero.

One assigned rating must be determined for each of the TS and US based on the texture of the horizons within each of these LCCS principal horizons. In Example 13, the TS principal horizon is comprised of two horizons of differing texture. Half of the TS (0 to 10 cm) has a SL texture, assigned rating of 2, and half of the TS (10 to 20 cm) has a CL texture, assigned rating of 3 (Table 10). The weighted texture rating for this TS is therefore 2.5 (50 % of 2 plus 50 % of 3). The US (20 to 50 cm) has a texture of CL, assigned rating of 3. The resultant cumulative rating for nutrient retention is TS + US = 2.5 + 3.0 = 5.5.

Example 13. Nutrient retention ratings for TS and US horizons of a natural soil.

Horizon Designation	Depth (cm)	Horizon Thickness (cm)	Texture	Assigned Rating	Weighted Average Calculation
LF	5-0	5	-	-	
Ae	0-10	10	SL	2	TS = 10/20 x (2) + 10/20 x (3) = 2.5
Bm	10-50+	40	CL	3	US = 30/30 x 3 = 3
					Σ = 2.5 + 3 = 5.5

4.3.4 SNR Cumulative Rating

Table 10 shows the class ranges for each soil nutrient parameter along with the corresponding assigned rating. The assigned ratings for each parameter are added, regardless of which class they fit under, to obtain the cumulative rating. The SNR index is assigned to the corresponding cumulative rating. The cumulative rating ranges reported in Table 10 are guidelines based on measured results from a, b, d and e ecosites (Boreal Mixedwood) in the Soil and Vegetation Plots. There is considerable variation and overlap among ecosites.

For the data presented in Example 12 and Example 13, 52.6 Mg ha^{-1} of C = assigned rating of 4; 3.4 Mg ha^{-1} of N = assigned rating of 4; a C:N ratio of 15 = assigned rating of 4; and a nutrient

4.3.3 NUTRIENT RETENTION FACTOR

A soil texture component is used to capture the importance of nutrient retention ability of finer-textured mineral materials. The points for topsoil and upper subsoil textures are based on increasing clay content, progressing from sand to finer materials, and associated cation exchange capacity for retaining nutrients in the absence of organic matter. Organic horizons (O horizons) are assigned a zero.

One assigned rating must be determined for each of the TS and US based on the texture of the horizons within each of these LCCS principal horizons. In Example 13, the TS principal horizon is comprised of two horizons of differing texture. Half of the TS (0 to 10 cm) has a SL texture, assigned rating of 2, and half of the TS (10 to 20 cm) has a CL texture, assigned rating of 3 (Table 10). The weighted texture rating for this TS is therefore 2.5 (50 % of 2 plus 50 % of 3). The US (20 to 50 cm) has a texture of CL, assigned rating of 3. The resultant cumulative rating for nutrient retention is TS + US = 2.5 + 3.0 = 5.5.

Example 13. Nutrient retention ratings for TS and US horizons of a natural soil.

Horizon Designation	Depth (cm)	Horizon Thickness (cm)	Texture	Assigned Rating	Weighted Average Calculation
LF	5-0	5	-	-	
Ae	0-10	10	SL	2	TS = 10/20 x (2) + 10/20 x (3) = 2.5
Bm	10-50+	40	CL	3	US = 30/30 x 3 = 3
					Σ = 2.5 + 3 = 5.5

4.3.4 SNR CUMULATIVE RATING

Table 10 shows the class ranges for each soil nutrient parameter along with the corresponding assigned rating. The assigned ratings for each parameter are added, regardless of which class they fit under, to obtain the cumulative rating. The SNR index is assigned to the corresponding cumulative rating. The cumulative rating ranges reported in Table 10 are guidelines based on measured results from a, b, d and e ecosites (Boreal Mixedwood) in the Soil and Vegetation Plots. There is considerable variation and overlap among ecosites.

For the data presented in Example 12 and Example 13, 52.6 Mg ha^{-1} of C = assigned rating of 4; 3.4 Mg ha^{-1} of N = assigned rating of 4; a C:N ratio of 15 = assigned rating of 4; and a nutrient

retention rating of 5.5, for a SNR cumulative rating of 17.5 (4+4+4+5.5), an overall medium SNR, and a SNR index of 15 (17.5 rounded to 18).

Table 10. Carbon, nitrogen, C:N, and nutrient retention assigned ratings and SNR indices.

Parameter		Poor	Medium	Rich
Organic Carbon Mg ha^{-1}		<35	35-70	>70
	assigned rating	**2**	**4**	**6**
Total Nitrogen Mg ha^{-1}	Natural	<1.5	1.5-5.0	>5.0
	Reclaimed	<3.0	3.0-5.0	>5.0
	assigned rating	**2**	**4**	**6**
C:N Ratio		>30	15-30	<15
	assigned rating	**2**	**4**	**6**
Nutrient Retention (Texture)		S = 0, LS = 1, SL = 2, Finer = 3, O = 0		
	assigned rating	**Sum = topsoil + upper subsoil**		

Cumulative Rating	6-8	9-12	13-17	18-21	22-24
SNR Index	**0**	**5**	**10**	**15**	**20**
SNR Subclass	**F**	**F**	**-**	**-**	**-**

Source: Information from the Soil and Vegetation Plots.

S = Sand, LS = Loamy Sand, SL = Sandy Loam, O = organic (>17% total organic carbon)

4.4 Limiting Factor Deductions

Once the base soil rating has been calculated (the sum of the SMR and SNR indices) horizon-dependent limiting factor deductions are calculated for the following factors:

- Soil structure and consistence: Subclass D
- Soil reaction (pH): Subclass V
- Soil salinity (electrical conductivity - EC): Subclass N
- Soil sodicity (sodium adsorption ratio - SAR): Subclass Y

First, the TS point deduction (b) is product of the Base rating (a) and the most limiting of structure, pH, EC, and SAR percent deductions. An Interim soil rating (c) is calculated and used in the calculation of the upper and lower subsoil deductions. The Interim soil rating is the difference between the base rating (a) and the TS deduction (b).

The US and LS principal horizons deductions (d and e, respectively) are calculated based on the Interim soil rating (c), not the Base rating as in the case for the TS, and are assigned a relative weighting of 2:1 (67 %:33 %, respectively). Refer to the Land Capability Worksheet (Appendix D) for more details.

As illustrated in Figure 1, natural horizon boundaries or reclamation material boundaries may not coincide with LCCS principal horizon boundaries. Where more than one natural soil horizon or reclamation material strata exists within an LCCS principal horizon, a weighted average of the deduction incurred is determined for that LCCS principal horizon. The Land Capability Worksheet (Appendix D) is intended to layout the land capability rating process and is useful for presenting simple examples. Additional space may be required for complex sites.

4.4.1 Soil Structure: Subclass D

Soil structure and related physical properties affect root penetration and availability of water, air and nutrients to plants, and are strongly influenced by soil texture, organic matter content, composition of exchangeable cations, freeze/thaw cycles, and biotic activity. Deductions are relatively subjective, based on descriptions of the class (size) and kind of structure (shape), as well as consistence of soil aggregates (resistance to crushing). Rooting characteristics may also

provide supporting evidence for the assessment process. Knowledge of soil structure and consistence classification is assumed. For guidance refer to the CanSIS manual (Working Group on Soil Survey Data, 1983).

Soil structure refers to the cohesion of individual soil particles into aggregates or "peds", and formation of large "compound structural units" from small peds, as a result of pedologic processes. Fragments are broken pieces of non-structured soil materials, and are observed when a soil mass is disrupted, resulting in ruptures along non-pedogenic planes of weakness, common in parent materials. Following is a list of guidelines for use of soil structure information in the LCCS.

- Structure and consistence are described for each horizon or strata occurring within the 1 m soil profile.
- Soil structure and consistence deductions apply only to mineral soils.
- No deductions are incurred for organic layers.
- No deductions for structure or consistence are incurred for mineral horizons where the consistence is loose, friable, or very friable.
- Table 11 and Table 12 present deductions for structure and consistence, respectively. Deductions for TS horizons are more severe than for subsoil horizons because of the greater effect of these parameters in surface soils on plant establishment, growth and survival.
- Amorphous (massive) soil structure has been assigned size classes to represent the size of fragments to which the material breaks down when a small force (*i.e.*, breaking apart by hands) is applied.
- The overall deduction for Structure (Subclass "D") is the sum of the percent deduction of structure and consistence as illustrated in Example 14.

In Example 14, the TS principal horizon is comprised of two horizons of differing structure. Because the total deduction for each of these two horizons is 0, the overall TS structure and consistence deduction is 0. If the two layers had differing total structure and consistence

deductions, a weighted average would be calculated to arrive at the overall TS deduction (as in nutrient retention Example 13).

Example 14. Structure and consistence deductions for a natural soil.

Horizon Designation	Depth	Structure				Consistence		Total
	(cm)	Grade	Size	Class	Deduction (%)	Type	Deduction (%)	Deduction (%)
LF	5-0	-	-	-	-	-	-	-
Ae	0-10	moderate	fine	platy	0	friable	0	0
Bm	10-60	moderate	coarse	subangular blocky	20	friable	0	0[1]
Ck	60-100	-	coarse	massive	20	firm	10	30

[1] Deduction of 0 because where consistence is loose, very friable, or friable, no structure deductions are incurred.

Table 11. Structure type, kind, class, size (CanSIS, 1983) and corresponding deductions for topsoil and subsoil.

Type	Kind	Class	Size (mm)	Deduction (%)	
				TS	US/LS
1. Structureless — no observable aggregation, no definite orderly arrangement around natural lines of weakness.	A. Single grain — loose, incoherent mass of individual particles, as in sands.	-	n/a	0	0
	B. Amorphous (massive) — a coherent mass showing no evidence of any distinct arrangement of soil particles.	Breaking to fine fragments:	<20	5	5
		Breaking to medium fragments:	20-50	20	20
		Breaking to coarse fragments:	50-100	20	20
		Breaking to very coarse fragments:	>100	50	50
2. Blocklike — soil particles arranged around a point and bounded by flat or rounded surfaces.	A. Blocky (angular blocky) — faces rectangular and flattened less than 5 sided, vertices sharply angular.	Fine blocky	<10	0	0
		Medium blocky	10-20	10	10
		Coarse blocky	20-50	30	30
		Very coarse blocky	>50	30	30
	B. Subangular blocky — faces subrectangular, more than 5 sided, vertices mostly oblique, or subrounded.	Fine subangular blocky	<10	0	0
		Medium subangular blocky	10-20	5	0
		Coarse subangular blocky	20-50	20	20
		Very coarse subangular blocky	>50	20	20
	C. Granular — spheroidal, characterized by approximately rounded vertices.	Fine granular	<2	0	0
		Medium granular	2-5	0	0
		Coarse granular	5-10	0	0
3. Platelike — soil particles arranged around a horizontal plane and generally bounded by relatively flat horizontal surfaces.	A. Platy — horizontal planes more or less developed.	Fine platy	<2	0	0
		Medium platy	2-5	0	0
		Coarse platy	>5	0	0
4. Prismlike — soil particles arranged around a vertical axis and bounded by relatively flat vertical surfaces.	A. Prismatic — vertical faces well defined and edges sharp.	Fine prismatic	<20	5	0
		Medium prismatic	20-50	20	20
		Coarse prismatic	50-100	20	20
		Very coarse prismatic	>100	50	50
	B. Columnar — vertical edges near top of columns not sharp. Columns may be flat-topped, rounded-topped, or irregular.	Fine columnar	<20	5	0
		Medium columnar	20-50	20	20
		Coarse columnar	50-100	20	20
		Very coarse columnar	>100	50	50

Table 12. Wet, moist, and dry consistence from CanSIS (1983) and corresponding deductions for topsoil and subsoil.

Wet Consistence	Moist Consistence	Dry Consistence	Deduction (%)
-	Loose	Loose	0
Nonsticky	Very friable	Soft	0
Slightly sticky	Friable	Slightly hard	0
Sticky	Firm	Hard	10
Very sticky	Very firm	Very hard	20
-	-	Extremely hard	30

4.4.2 Soil Reaction (pH): Subclass V.

A slightly acidic soil condition is the ideal situation for a balanced nutrient supply (Brady and Weil, 1996). Soils more acidic than pH 5.0 may result in decreased forest productivity. At pH levels below 4.0, some elements may be present in toxic concentrations. High pH or alkaline conditions reduce bioavailability of phosphorus and most micronutrients. High pH is often associated with saline and sodic conditions, which can further affect plant performance. Percent deductions for soil pH (determined in H_2O) are presented in Table 13, and their application illustrated in Example 15. Note that deductions for topsoil and subsoil are slightly different and that not all pH ranges are of equal increments (pH 4.1-4.3 and 4.4-5.0). The accepted convention is to use pH measurements determined in water. For evaluating previous results where pH was determined in $CaCl_2$, add 0.5 units to pH values <7.5 and do not change pH values of 7.5 and greater.

Table 13. Topsoil and subsoil reaction deductions for soil pH (measured in H_2O).

pH range	Deduction (%)	
	TS	US/LS
≤3.5	80	80
3.6 – 4.0	60	60
4.1 – 4.3	40	40
4.4 – 5.0	15	15
5.1 – 5.5	0	0
5.6 – 6.0	0	0
6.1 – 6.5	0	0
6.6 – 7.0	0	0
7.1 – 7.5	10	10
7.6 – 8.0	25	20
8.1 – 8.5	40	40
8.6 – 9.0	60	60
≥9.0	80	80

Example 15. Soil reaction (pH measured in H_2O) deductions for a reclaimed soil.

Horizon Designation	Depth (cm)	Horizon Thickness (cm)	pH	Deduction (%)	Weighted Average Calculation
Ptmix	0-10	10	6.0	0	TS = 10/20 x 0 + 10/20 x 10 = 5%
MIN	10-60	50	7.3	10	US = 30/30 x 10 = 10%
TSS	60-100	40	8.0	20	LS = 10/50 x 10 + 40/50 x 20 = 18%

4.4.3 Soil Salinity (EC): Subclass N

Salinity refers to the presence of excessive concentrations of soluble salts, such as sodium and magnesium sulphates. Salts can adversely affect plant growth due to chemical effects and by reducing water availability to plants through an increase in soil osmotic potential. Soil salinity is expressed in terms of electrical conductivity (EC) in dS m^{-1} and is determined in a saturated paste extract. Figure 4 presents deductions for soil salinity.

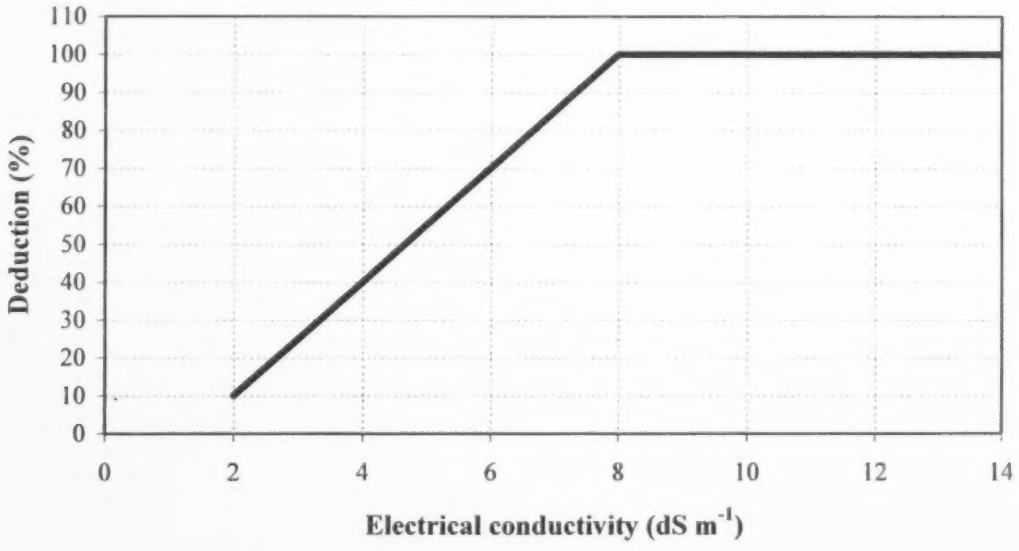


Figure 4. Soil salinity deductions.

No deductions are incurred where the EC (dS m^{-1}) is less than 2. For the sloped part of the line (EC of 2 to 8), the percent deduction is calculated according to Equation 3. An example is presented in Example 16.

Equation 3. Soil salinity deductions for EC of 2 to 8 dS m^{-1}.

Deduction (%) = 15(EC) - 20

Example 16. Soil salinity (EC) deductions for a reclaimed soil.

Horizon Designation	Depth (cm)	Horizon Thickness (cm)	EC ($dS\ m^{-1}$)	Deduction (%)	Weighted Average Calculation
Ptmix	0-10	10	0.2	0	TS = 10/20 x (0) + 10/20 x (0) = 0%
MIN	10-60	50	1.0	0	US = 30/30 x 0 = 0%
TSS	60-100	40	2.4	16	LS = 10/50 x (0) + 40/50 x (16) = 13%

4.4.4 Soil Sodicity (SAR): Subclass Y

Sodic soils are those soils that contain high concentrations of soluble sodium. As the sodium adsorption ratio (SAR) increases above 12 (usually associated with a pH over 8.5) the stability of soil aggregates decreases markedly. The finer particles (clays and organic matter) become dispersed, resulting in adverse physical conditions (*i.e.*, massive and sticky when wet and extremely hard when dry).

Deductions for soil sodicity are presented in Figure 5. No deductions are incurred if the SAR is less than 4. **If the texture is SL or coarser do not deduct for SAR, because dispersion of the low proportion of clays should not result in a serious impact on soil structure.**

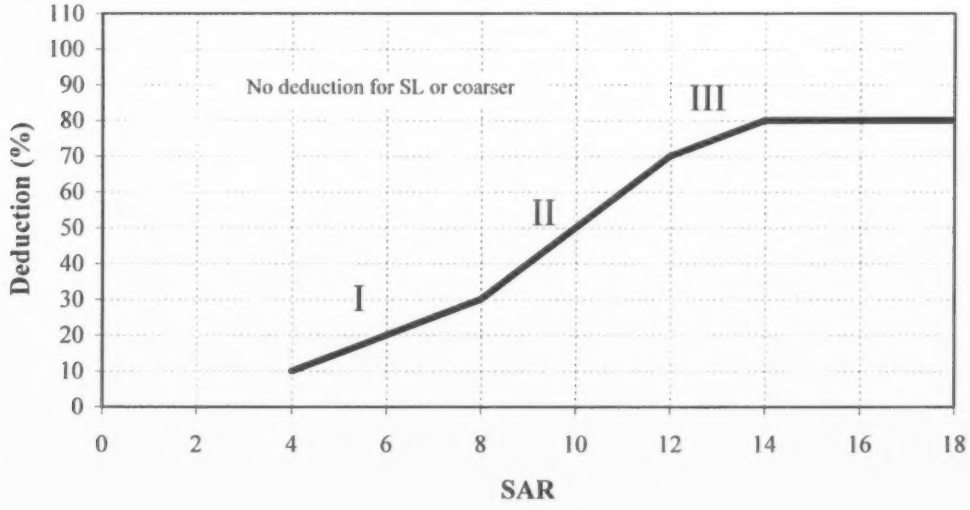


Figure 5. Soil sodicity deductions.

The relationship presented in Figure 5 has three distinct slope segments between SAR values of 4 and 14, inclusive. Table 14 presents the linear functions that represent each of these slope segments. An example is presented in Example 17.

Table 14. Linear functions for calculation of percent deductions for SAR.

Slope Segments	SAR Range	Deduction (%)
-	<4.0	0
I	≥4.0-8.0	$\text{Deduction (\%)} = 5(\text{SAR}) - 10$
II	>8.0-12	$\text{Deduction (\%)} = 10(\text{SAR}) - 50$
III	>12-14	$\text{Deduction (\%)} = 5(\text{SAR}) + 10$
-	14+	80

Example 17. Soil sodicity (SAR) deductions for a reclaimed soil.

Horizon Designation	Depth (cm)	Horizon Thickness (cm)	SAR	Deduction (%)	Weighted Average Calculation
Ptmix	0-10	10	0.5	0	TS = 10/20 x (0) + 10/20 x (18) = 9%
MIN	10-60	50	5.6	18	US = 30/30 x 18 = 18%
TSS	60-100	40	10.1	51	LS = 10/50 x (18) + 40/50 x (51) = 44%

5.0 Mapping Applications

For the purpose of reporting, land capability tables, spreadsheets, and maps must show the land classes and subclasses. However, when tabulating total hectares per class it is not necessary to differentiate subclasses. It is desirable to maintain simplicity and precision, hence "pure" units should be mapped to avoid complexes where possible. Table 15 outlines mapping protocols with respect to delineation of land areas or map polygons. Similar units are considered to be within one class of each other; for example, Classes 1 and 3 are similar to Class 2. Contrasting units differ by two or more classes, hence, Class 2 and 4 are contrasting units.

Where there is variation in soils, landscapes, and resultant capabilities, complexes are necessary. Conventions for designating composition of polygons are shown in Table 16. Methods used in any given report should be referenced or explained/justified if different. The information in Table 15 and Table 16 was developed by a Task Group (2003) commissioned by the SVSG.

Table 15. Mapping conventions regarding polygon size.

Polygon Size Diameter	Area	Mapping Protocol for Pure/Complex Units[1]	Comments
<20 m	<0.04 ha (<400 m^2)	Disregard unless it exceeds 10 %, then include in complex	Must be safe, stable
20-100 m	0.04 – 1 ha	Spot symbol (Δ) applies to contrasting units	Fixable operators/regulators discretion
100-500 m	1-25 ha	Map polygon pure units	Fixable operators/regulators discretion
>500 m	>25 ha	Map polygon pure or complex units	General management portions of classes apply

[1] Contrasting unit: 2 or more class difference in capability.

Table 16. Mapping conventions to indicate purity of soil polygons.

Capability (example)	Description of Polygon Purity
Pure Class (3S)	>90 % of the polygon contains soils in the designated class or one class higher or lower (similar soils); over 75 % of soils should be in designated class.
Complex of Classes ($3S^7$, $4MD^2$, $5W^1$)	Each class is shown and its proportion to the nearest 10% is indicated by a decile superscript 1 to 9 representing 10 to 90 %, respectively. Use a maximum of 3 classes. No superscript means 100 %. Contrasting soils should be given priority over similar soils.

6.0 References

Alberta Land Conservation and Reclamation Council. 1991. A Guide to the Preparation of Applications and Reports for Coal and Oil Sands Operations. Edmonton, Alberta.

Alberta Soils Advisory Committee (ASAC). 1987. Soil Quality Criteria Relative to Disturbance and Reclamation (revised). Alberta Agriculture. 56 pp.

Ballard, R. 1984. Fertilization of Plantations. pg. 327-360. *In* G.D. Bowen and E.K.S. Nambiar, Eds. Nutrition of Plantation Forests. Academic Press.

Beckingham, J.D. and J.H. Archibald. 1996. Field Guide to Ecosites of Northern Alberta. Nat. Resour. Canada., Can. For. Serv., Northwest Reg., North. For. Center, Edmonton, Alberta. Spec. Rep. 5.

Brady, N. and R. Weil. 1996. The Nature and Properties of Soils. Prentice Hall, Inc.

Alberta Environment. 1998. C&R/IL/98-7 Conservation and Reclamation Information Letter: Land Capability Classification for Forest Ecosystems in the Oil Sands Region (Revised). http://www.gov.ab.ca/env/protenf/landrec/index.html

Carter, M.R. (Ed.). 1993. Soil Sampling and Methods of Analysis. Canadian Society of Soil Science. Lewis Publishers. Boca Raton, Florida.

Chaikowsky, C.L. 2003. Soil Moisture Regime and Salinity on a Tailings Sand Storage Facility. M.Sc. Thesis, University of Alberta. Edmonton, AB. 135 pp.

Crepin.J and R.L. Johnson. 1993. Soil sampling for environmental assessment. Pg. 5-13 *In* M.R. Carter, Ed. Soil sampling and methods of analysis. Canadian Society of Soil Science. Lewis Publishers. Boca Raton, Florida.

Canadian Society of Soil Science.Boca Raton, Florida.Expert

Committee on Soil Survey. 1987. Soil Survey Handbook Volume 1. Land Resource Research Center, Contribution Number 85-30, Technical Bulletin 1987-9E. Research Branch, Agriculture Canada.

Mapping Systems Working Group. 1981. A soil mapping system for Canada, Revised. Land Resource Research Institute Contribution No. 142. Research Branch, Agriculture Canada. Ottawa, Ontario. 94 pp.

McKeague, J.A. (Ed.). 1978. Manual on Soil Sampling and Methods of Analysis. 2nd ed. Canadian Society of Soil Science.

Miller, H.G. 1984. Dynamics of Nutrient Cycling in Plantation Ecosystems. pg. 53-78. *In* G.D. Bowen and E.K.S. Nambiar, Eds. Nutrition of Plantation Forests. Academic Press.

Moskal, T.D. 1999. Moisture Characteristics of Coarse Textured Soils and Peat:Mineral Mixes. M.Sc. Thesis, University of Alberta. Edmonton, AB. 139 pp.

O'Kane, M. 2003. Analytical Evaluation of Available Water Holding Capacity for the Syncrude Canada Ltd. Reclamation Cover Systems. Memo presented to Soil and Vegetation Working Group.

Oil Sands Vegetation Reclamation Committee. 1998. Guidelines for Reclamation to Forest Vegetation in the Athabasca Oil Sands Region. Alberta Environment, Edmonton, AB.

Province of Alberta. 2003. Environmental Protection and Enhancement Act and Regulations. Revised Statutes of Alberta 2000 Chapter E-12, with amendments in force as of December 18, 2003. Alberta Queen's Printer.

Soil Classification Working Group. 1998. The Canadian System of Soil Classification. NRC Research Press. Ottawa. 187 pp.

Working Group on Soil Survey Data. 1983. The Canadian Soil Information System (CanSIS): Manual for Describing Soils in the Field. Agriculture Canada, Ottawa, Ontario.

Yarmuch, M. 2003. Measurement of Soil Physical Parameters to Evaluate Soil Structure Quality in Reclaimed Oil Sands Soils, Alberta, Canada. M.Sc. Thesis, University of Alberta. Edmonton, AB. 134 pp.

Appendix A. Soft-Spots List

Appendix A. Soft-Spots List.

The *Land Capability Classification System for Forest Ecosystems* (LCCS) manual can be considered a working document to facilitate evaluation of land capabilities for forest ecosystems for natural and reclaimed lands in the Athabasca Oilsands Region of Alberta. In 2005, some improvements were made as compared to the 1998 edition, particularly in rating of the soil nutrient regime. With the completion of research projects in the region, the LCCS should be progressively improved over time.

The LCCS makes numerous assumptions, which may or may not be tenable. There are several sources of uncertainty, which may confound predictions based on it. Yet the intent of the LCCS is such that it cannot eliminate all uncertainty, nor avoid making assumptions. At best, it can reduce the uncertainty and discard untenable assumptions.

Definition of soil capability requires identification of key attributes, based on the ecosystem functions that soil provides in support of forest growth. It also involves measurement or estimation of these attributes, and their integration into a soil capability rating. One source of uncertainty in this estimation lies in the relationship between soil and landscape capability on the one hand, and forest productivity on the other. The assumption extends to how the latter is measured, and the issue of whether relationships defined for natural soils also apply to reclaimed landscapes. This uncertainty has been identified in several reviews of the LCCS by forestry experts.

The following table is a list of "soft spots", or acknowledged uncertainties/information gaps, compiled by members of the Soil and Vegetation Subgroup during the process of manual revision. Over time, assuming the items in the "soft-spot" list will be addressed through research and monitoring programs, more confidence may be placed in the LCCS for assessing natural and reclaimed landscapes. However, given current lack of understanding of some key components of the system, the LCCS should be used as a tool, not as a prescription, and it is critical for operators to understand that the LCCS is not meant to be used as a recipe for reclamation. There are other components of the EPEA approvals, including the minimum placement requirements, the Site Index Productivity, the Mine Reclamation Plan, and the Life of Mine Closure Plan that contribute to building a successfully reclaimed ecosystem. As a final test, a site must meet the

criteria for reclamation certification. It is in the operator's best interest to ensure that all steps are taken to ensure reclamation certification will occur in a timely fashion.

Specific comments regarding the "Soft-spot list" generated by the SVSG is presented in the following table.

Table A. Soft-spots list for LCCS.

Issue	Comments	Actions to address
Forest productivity, site index, and relationships to soil properties	**Soil-Site Productivity Relationships** Provide a detailed breakdown of the research and/or literature reviews and decisions needed to resolve the uncertainty over current reclamation treatments and land ratings and actual vegetation performance, particularly for thinner reclamation caps or marginal Class 3-4 treatments.	Recommendations to be derived from review of forest productivity work conducted by JS Thrower and Associates. These recommendations, and those made by group members, will be integrated into future (2006 and on) plot network measurement, as well as other research/monitoring programs as required.
	Site Index is only one measure of long-term productivity and needs to be supplemented with other markers of long-term ecosystem viability/sustainability.	Group is initiating "Indicators of Ecosystem Function" proposal to identify indicators alternative to site index of long-term ecosystem viability/sustainability.
Sampling protocol	Overall sampling design should be consistent with both research and operational monitoring, and be integrated with FRP (Forest Resource Plan) Growth and Yield requirements	Sampling task group to address.
Soil moisture regime (SMR)	**AWHC modifiers** Proper research data and more literature results are needed to compare the relative magnitude of impact to soil moisture regime by textural bands, slope aspects, and slope locations. On the landscape, it appears that the impact of slope steepness, slope aspect, and slope location are the major factors that determine the drainage system. The texture of soils appears to have a localized effect on internal drainage and moisture distribution inside a pedon. The magnitude of point deductions for slope position and slope aspect, compared to that for textural bands and material strata (Section 4.2) in the LCCS manual, are questionable. Protocol development should be based on validated models and well-founded information.	SVSG to initiate, in 2005/06 programs to quantify layering effects (U of S, L. Barbour, 2006), and moisture properties of coarser-textured materials (glaciofluvial overburden and coarse tails) (ARC, 2005)

Issue	Comments	Actions to address
Soil moisture regime (SMR)	**Water-repellent modifier** The upgrade of soil moisture regime based on the presence of a lean oil sand layer is controversial. This approach is not balanced; it has not considered the possible toxic effects of hydrocarbons to a range of tree species and the impact of soil moisture availability below the lean oil sand layer in a soil profile. The application of this modifier to water-repellent lean oil sand may not be sufficiently conservative.	Hydrocarbons in soil research (toxicological effects and degradation kinetics) (S. Visser, U of C, 2005). Instrumented watersheds on lean oil sands (hydrologic and physical effects) (Albian, Syncrude and Suncor).
	Slope/aspect modifier Table 8 specifies SMR modifiers for various slope position and aspect combinations. These modifiers are based on a generalized understanding of these relationships, but is neither field tested nor able to account for complexities introduced by complex topography.	Current research on "Instrumented Watersheds" seeks to better quantify the relationship between site climatic conditions and soil moisture conditions. This research will be applied to the manual as it becomes available.
	Subhygric and wetter moisture regimes Reclaimed soils have had insufficient time to develop critical indicators (mottling and tree growth/performance) required for the identification of Subhygric and Hygric aerated moisture regimes. For natural soils, water table and mottle relationships are not sufficiently understood to allow standardization of moisture regime determination based on these parameters.	
	SMR to SNR relationship SMR accounts for 80% of the base land rating in the current model of the LCCS, with SNR accounting for 20%. The validity of this weighting has not been demonstrated and continued research is necessary to refine this weighting.	
Organic surface (O)	Uncertainties around the effect of peat on soil quality and forest productivity, and risk of fire. Need to understand the mineral nutrient component, CEC and AWHC uncertainty due to the percentage of Organic Matter in the soil profile.	SVSG to develop a project to provide context for potential ground-fire problem through a risk-based assessment. Assess the combustion potential of peat-mineral mixes and existing reclamation areas based on OM type and content in the soil horizon, carefully considering the variation induced by varying placement and materials handling methodologies.

Issue	Comments	Actions to address
Organic surface (O)	Effects of peaty surface may be related to more issues than moisture retention. Future action may be to conduct a literature review to address moisture retention, decomposition, heat reflection, *etc*, as well as impacts of high organic content when applied at high levels (*i.e.*, up to 1.0 m thick) on variables like cold soils/permafrost, *etc*.	
Soil nutrient regime (SNR)	To return to equivalent land capability, original mineral or organic materials found on site, before land-disturbance, should be conserved and used to conduct reclamation, as those natural materials have similar natural nutrient storage and characteristics. Extreme caution should be exercised in using engineered materials unless overall beneficial effect to the land and the ecosystem is solidly demonstrated and sustainable.	
	The current LCCS model uses organic carbon capital, carbon: nitrogen ratio, and silt/clay content to determine SNR. Uncertainties around the contributions of other micro and macronutrients remain. Inclusion of additional nutrients (*e.g.* phosphorus) in this index should be considered. Phosphorus is the preferred element to replace Ca as a nutrient parameter.	Evaluation of the potential of available nutrients (*e.g.*, P, K, Mg, Zn, Fe) and/or their ratios for determining the SNR index will be undertaken following analysis of foliar and upper subsoil chemistry data.

Issue	Comments	Actions to address
Soil nutrient regime (SNR)	The LCCS may not deal adequately with soil organic matter (SOM) specifically in comparing peat and peat mineral mixes to natural L, F, and H horizons. Notwithstanding the differences between agricultural and forest soils, SOM is of fundamental importance, especially to the long-term productivity of a site. Yet, because the amount of SOM at steady state is the difference between inputs from vegetation through litter and its decomposition, it cannot be measured at the time of placement of the reclamation materials or shortly thereafter. Inputs of organic C will change as vegetation changes at the site, especially in forests. This will affect nutrient cycling, and N dynamics in particular. SOM also affects soil structure and water-holding capacity. Numerous models are currently used for predicting SOM dynamics. They also provide an integrated description of the factors that determine SOM content.	Sylvie Quideau's/Cindy Prescott's collaborative program. Investigate program to evaluate Von Post scale of decomposition as potential parameter for determination of SNR. Look at SOM models (mentioned on the left)?
	Uncertainties around nutrient contributions of "deeper" mineral soil (LCCS upper subsoil). The current LCCS model does not recognize the nutrient contribution of the 20-50 cm material that may provide significant nutrient contribution to long-term forest productivity (White and McNabb, 2004).	Upper subsoil horizons to be analyzed in 2005 field program.
	Uncertainties around which method of measuring nitrogen availability is most appropriate. Mineralizable N should be evaluated as a potential input to the LCCS for SNR determination.	Mineralizable nitrogen to be analyzed in 2005 field program.
	The SNR rating system (Table 10) includes a rating system based on topsoil and upper subsoil texture. This system is based on general understanding of fine soil fraction contributions to nutrient retention and release. However, the system's thresholds and weighting are based on specific understanding of these relationships, and may require re-evaluation.	

Issue	Comments	Actions to address
	Tailings sand has different characteristics that may affect soil nutrient capability.	Coarse textured soil research:
	Compare natural sand and tailing sands to determine, for each of the operating mines, if adjustments to LCCS soil rating are required.	moisture properties of coarser-textured materials (glaciofluvial overburden and coarse tails) (ARC, 2005).
Soil nutrient regime (SNR)	Many or most of the reclaimed area is fertilized at least once and sometimes several times in the first decade. This creates uncertainty over the value of soil characterizations, as observations on ecosystem health and tree growth in this early phase may be driven by fertilization. It is difficult to assess the true state of nutrient cycling/ecosystem functioning and so the calculated land ratings are likely to be inaccurate.	Investigate the role of fertilization on these unique soils and the impact on land ratings. Consider whether the long-term sustainability of the reclaimed soils can be evaluated with early fertilization driving the system; balance this against the possible startup dynamics where early fertilization may establish nutrient cycling. Determine a program of study to investigate issue and adjust LCCS accordingly.
Limiting factor deductions	Cl^- may retard plant growth	Evaluate the effects of Cl^- as a component that requires a scale of deductions.
Structure and Consistence (D)	Structure and consistence deductions are based on a generalized understanding on the effects of soil root occupancy and plant growth. These deductions are not based on specific understanding of these relationships, and may require re-evaluation.	
Soil salinity	Other related literature on trees and salinity exists and should be consulted in future revisions of the LCCS.	
	Movement of salts from subsoils to rooting zones may affect site productivity over the long term. Work by L. Barbour (S. Kessler MSc. Thesis, unpublished) indicates that the diffusion gradient on saline-sodic overburden is 15 cm. Additional research evaluating the effect of soil cover depth, soil type, and volume of biomass should be initiated.	
	Natural plot network does not contain any naturally saline sites, precluding the ability to calibrate the LCCS for salts.	Identify salt-affected sites and include in plot network. Determine effect to growth, by species, for increasing levels of Cl^-, Na and other contributors of salinity. 2005-6 work partially funded by SVSG (B. Purdy, U of A).

Issue	Comments	Actions to address
Hydrocarbons	Manual does not currently consider the effects of hydrocarbons in soil on tree productivity.	Hydrocarbons in soil research (toxicological effects and degradation kinetics) (S. Visser, U of C, 2005). Instrumented watersheds on lean oil sands (hydrologic and physical effects) (Albian, Syncrude and Suncor).
Model	**LCCS principal horizons and weightings** A more extensive literature review to cover common tree species along with field observations should be integrated to deal with this issue. Input from professional foresters and ecologists is needed to adequately address this issue. It appears that deeper depth is needed to deal with dry and sandy sites for some species, or to protect trees from salt damage.	
	Is a 1-m profile appropriate (xeric)? Some sites of xeric character may necessitate up to a 3 m depth evaluation in order to properly evaluate the required rooting depth considering moisture limitations	Initiate review of assessment depths in light of published rooting depths observed for boreal tree species on varying moisture regimes.
	Is a 1-m profile appropriate (Jack pine)? Jack pine rooting depth in sandy slopes with shallow (<1m) depth to inhospitable rooting material. Is this included in the "model" issue above?	Determine depth of root zone that is important for Jack pine growth and survival on sand substrates, related to above.
	Most limiting factor approach for structure, pH, EC, and SAR. Is the "most limiting" approach for limiting factors appropriate? Could effects be cumulative?	Determine which factors are cumulative and need to be considered with additive deductions.
Limiting factor deductions	The LCCS has progressed to the point where it should address how factors are combined into a single rating. Given the number of variables considered, some of the information included may provide little or no benefit in terms of increasing the predictive power of the system. The reason for this is covariance among variables. This is especially true for the soils component.	

Issue	Comments	Actions to address
Interactive effects of vegetation and material placement	The salvage and use of upland forest LFH direct placement and woody debris to reclamation sites should contribute to soil rating in the LCCS.	Evaluate these variables for inclusion in future edition of the LCCS.
Indicators of success	Soil parameters and site index alone may not be sufficient indicators of successful reclamation. Other indicators of ecosystem function/health should be evaluated to validate the LCCS rating.	SVSG issuing RFP to determine list of candidate indicators.
Peer Review	A formal peer review of the entire LCCS manual will be conducted and recommendations of the reviews added to the list of soft spots to resolve prior to September of 2009.	Consider commissioning peer review after this release (rather than 2008) so issues found can be resolved prior to 2009 release.

Appendix B. Suggested Reclaimed Horizon Designations

Appendix B. Suggested Reclaimed Horizon Designations

L, F, and H — As described in the Canadian System of Soil Classification (Soil Classification Working Group, 1998). These horizons will develop on reclaimed sites over time.

O — This organic layer (having 17% or more organic carbon by weight) occurs where insufficient mineral material has been incorporated with organic materials. Applies to surface and buried layers. Buried "O" layers are those with 10 cm or more mineral material (having less than or equal to 17 % organic carbon by weight).

OB — Refers to undifferentiated overburden material.

MIN — This mineral layer is low in organic matter and does not meet the criteria for Ptmix or O layers. It is salvaged and replaced mineral overburden that does not meet the criteria for R, KM, or KC. It is a dominant mineral component of many reclaimed landscapes.

TSS — Tailings sand is the coarse mineral by-product of the oil extraction process. It is a dominant mineral component of reclaimed tailings structures where it occurs as the substrate. It can also be found as a surface horizon (windblown).

R — This consolidated bedrock layer is too hard to break with hands (>3 on Moh's scale) or to dig with a spade when moist (Soil Classification Working Group, 1998).

KC — This mineral layer originates from the Cretaceous Clearwater formation. It is saline-sodic, dispersive, and relatively impermeable to water. When it occurs, it is typically a component of the lower soil profile (substrate).

KM — This oil-impregnated sand originates from the Cretaceous McMurray formation. The total hydrocarbon content can vary significantly. When it occurs, it is typically a component of the lower soil profile (substrate). It is often referred to as lean oil sand (LOS).

Ptmix — This mineral layer is enriched with organic mater (peat), but not so much to be classed as and "O" layer (see above).

Appendix C. Site and Soil Description Form

Appendix C. Site and Soil Description Form

Location/Site		Assessment date		
Map Unit/Soil Series		Assessor(s)		
Soil Classification		Ecosite	a b c d e f g h i j k l	
Parent Material	Genetic: Expression:	Type	Natural ☐ Reclaimed ☐	
Drainage	VR R W MW I P VP	Site Index and Species	Species: Height: Age:	Site Index:
Soil Moisture Regime	1 2 3 4 5 6 7a 7b 8 9	Stand Quality	High Moderate Low Non-Productive	
Soil Nutrient Regime	P M R	Compaction	None Sli Mod Sev V.Sev Ext	
Topography	Percent: Position: Aspect:	Notes		
Coarse Fragments (% vol. to 1 m)	Gravel: Stones:			
Depth to water table (cm)				
Samples				

Horizon	Depth	Color	Texture	Structure			Consistence	Mottles			Impermeable	Coarse Fragments (%)	Sample ID
				Grade	Size (mm)	Kind		Abundance	Size	Contrast			

Analytical results

Site Id	Sample ID	Thickness (cm)	TOC (%)	Total nitrogen (%)	Bulk density (Mg m^{-3})	Clay (%)	Sand (%)	Silt (%)	Texture	pH (H_2O)	EC (dS m^{-1})	SAR

Appendix D. Land Capability Worksheet

Appendix D. Land Capability Worksheet.

SOIL MOISTURE REGIME INDEX AND SUBCLASS DETERMINATION

Water table ≤100 cm[1]

Moisture regime	SMR Index and Subclass	Description	Surface organic thickness (cm)	Water table depth (cm)
Subhygric (6)[2]	80	Water removed slowly enough to keep the soil wet for a significant part of the growing season; some temporary seepage and possible mottling below 20 cm.	10 - 40	May be <100
Hygric (7a)[2]	66	Hygric aerated: Water removed slowly enough to keep the soil wet for most of the growing season; mottling present within 50 cm.	16 - 40	30-100
Hygric (7r)[2]	24W	Hygric reduced: Water removed slowly enough to keep the soil wet for most of the growing season; >50% gley within 50 cm.	16 - 40	30-100
Subhydric (8)	0W	Water removed slowly enough to keep the water table at or near surface for most of the year; organic and gleyed mineral soils; permanent seepage < 30 cm below soil surface.	> 40	0-30
Hydric (9)	0W	Water removed so slowly that the water table is at or above the soil surface all year; organic and gleyed mineral soils.	> 40	0+

[1] Circle the appropriate SMR index and subclass based on soil and landscape description, surface organic thickness, and water table depth.

[2] Subhygric and hygric moisture reqimes are not to be applied to reclaimed soils at this time.

Note: additional indicators can be found in Table 9.

AWHC Calculation (water table >100 cm; no gleying)

Horizon Designation	Texture	Horizon Thickness (cm)	Multiplier	AWHC (mm)	% coarse fragments adjustment (vol.)	(mm)	AWHC (mm)

Profile AWHC = Σ _____ (i)

Layering modifiers

Check box if soil profile information above meets the criteria for one of the layering modifiers for a 15 mm upgrade.

Impermeable layer ☐ _____

Coarse over fine material stratification ☐ _____

Fine over coarse material stratification ☐ _____

Layering effect = _____ (ii)

Subclass 'O' where ≥15 cm O horizon beginning at 0 cm (reclaimed soils).

Subclass 'P' where % coarse fragments adjustment is ≥30 mm

Subclass 'Z' where R, KC, IMP, or i horizon occupies ≥30 cm of the profile.

Landscape Modifiers (≥10% slopes)

Aspect (degree range)	Crest 1	Upper 2	Mid 3	Lower 4	
					(iii)

Circle applicable slope and aspect combination; toe, depression and level = 0.

Adjusted AWHC

Adjusted AWHC = (i) + (ii) + (iii) = _____ (i) + _____ (ii) + _____ (iii) = _____

Moisture regime	SMR Index and Subclass	Adjusted AWHC (mm $100cm^{-1}$)
Very xeric (1)	10X	< 56
Xeric (2)	24X	56 – 85
Subxeric (3)	38X	86 – 115
Submesic (4)	52	116 – 145
Mesic (5)	66	146 – 175

SMR, SMR index and Subclass

Soil Moisture Regime _____

SMR Index _____

Subclass -

SOIL NUTRIENT REGIME INDEX AND SUBCLASS DETERMINATION

Total C, N and C:N

Horizon Designation	Depth (cm)	Horizon thickness (cm)	Bulk density (Mg m^3)	TOC (%)	TOC (Mg ha^{-1})	Total Nitrogen (%)	Total Nitrogen (Mg ha^{-1})
				Σ			Σ
				C:N			

Nutrient retention rating

Horizon Designation	Depth (cm)	Horizon thickness (cm)	Texture	Assigned rating	Weighted average calculation

Cumulative rating

Parameter		Value				Rating
Organic Carbon	(Mg ha^{-1})					
Total Nitrogen	(Mg ha^{-1})					
C/N ratio						
Nutrient Retention[1]		TS		US		

[1] Weighted average calculation may be required.

Cumulative rating Σ

Soil Nutrient Regime Index and Subclass SNR

Base rating

Base Rating = SMR Index + SNR Index = SMR Index + SNR index = _____ (a)

Subclass(es) = _____ _____

LIMITING FACTOR DEDUCTIONS

Weighted average calculations must be performed as required.

Topsoil Adjustment (0-20 cm)

Factor		Value	Deduction	Subclass
Structure/Consistence			%	D
Reaction	pH		%	V
Salinity	EC (dS m^{-1})		%	N
Sodicity	SAR		%	Y

TS deduction (b) **(b)** = (most limiting of D, V, N, Y%)(a)

(b) = (_____)**(a)** = _____ **(b)**

Interim soil rating (c) **(c)** = (a) – (b)

(c) = (_____) - (_____) = _____ **(c)**

Upper Subsoil Adjustment (20-50 cm)

Factor		Value	Deduction	Subclass
Structure/Consistence			%	D
Reaction	pH		%	V
Salinity	EC (dS m^{-1})		%	N
Sodicity	SAR		%	Y

US deduction (d) **(d)** = (most limiting of D, V, N, Y%)(c) (0.67)

(d) = (_____)(_____)(0.67) = _____ **(d)**

Lower Subsoil Adjustment (50-100 cm)

Factor		Value	Deduction	Subclass
Structure/Consistence			%	D
Reaction	pH		%	V
Salinity	EC (dS m^{-1})		%	N
Sodicity	SAR		%	Y

LS deduction (e) **(e)** = (most limiting of D, V, N, Y%)(c) (0.33)

(e) = (_____)(_____)(0.33) = _____ **(e)**

Final Land rating = (a) – (b) – (d) – (e)

Final Land Rating = (_____) – (_____) – (_____) – (_____) = _____

Land capability rating ranges	Land capability class
81-100	Class 1
61-80	Class 2
41-60	Class 3
21-40	Class 4
0-20	Class 5

Land capability rating: _____

Land capability class: _____

Subclass(es): _____

Appendix E. Example Site and Soil Description and Land Capability Worksheet

Appendix E. Example Site and Soil Description and Land Capability Worksheet

Site and Soil Description Form

Location/Site	*1*	Assessment date	*May 24, 2006*	
Map Unit/Soil Series	*Dover*	Assessor(s)	*CEMA*	
Soil Classification	*Orthic Gray Luvisol*	Ecosite	a b c [*d*] e f g h i j k l	
Parent Material	Genetic: *Glaciolacustrine* Expression: *Undulating*	Type	Natural ☐ ☑ Reclaimed ☐	
Drainage	VR R W [*MW*] I P VP	Site Index and Species	Species: *White Spruce* Height: *14 m* Age: *36 years*	Site Index: *19*
Soil Moisture Regime	1 2 3 4 [*5*] 6 7a 7b 8 9	Stand Quality	High [*Moderate*] Low Non-Productive	
Soil Nutrient Regime	P [*M*] R	Compaction	[*None*] Sli Mod Sev V.Sev Ext	
Topography	Percent: *3* Position: *Midslope (C)* Aspect: *90° (East)*	Notes		
Coarse Fragments (% vol. to 1 m)	Gravel: *<2%* Stones: *0%*			
Depth to water table (cm)	*> 100 cm*			
Samples	*4*			

Horizon	Depth	Color	Texture	Structure			Consistence	Mottles			Impermeable	Coarse Fragments (%)	Sample ID
				Grade	Size (mm)	Kind		Abundance	Size	Contrast			
LFH	12-0	10YR 2/1m	-	-	-	-	-	-	-	-	-	0	1-LFH
Ae	0-15	10YR 7/1d	L	S	2-5	PL	Friable	-	-	-	-	<2	1-Ae
Bt	15-50	10YR 3/2m	C	M	10-20	SBK	Friable	-	-	-	-	<2	1-Bt
BC	50-100	10YR 5/3m	C	M	<20	MA	Firm	-	-	-	-	<2	1-BC

Analytical results

Site Id	Sample ID	Thickness (cm)	TOC (%)	Total nitrogen (%)	Bulk density ($Mg\ m^{-3}$)	Clay (%)	Sand (%)	Silt (%)	Texture	pH (H_2O)	EC ($dS\ m^{-1}$)	SAR
1	1 - LFH	12	27.1	1.06	0.15	-	-	-	-	5.5	-	-
1	1 – Ae	15	0.52	0.02	1.65	20	36	44	L	4.6	0.3	1.0
1	1 – Bt	35	0.25	0.01	1.60	58	9	33	C	5.0	0.3	1.0
1	1 – BC	50	-	-	-	53	19	28	C	6.6	0.35	1.6

LAND CAPABILITY WORKSHEET

SOIL MOISTURE REGIME INDEX AND SUBCLASS DETERMINATION

Water table ≤100 cm[1]

Moisture regime	SMR Index and Subclass	Description	Surface organic thickness (cm)	Water table depth (cm)
Subhygric (6)[2]	80	Water removed slowly enough to keep the soil wet for a significant part of the growing season; some temporary seepage and possible mottling below 20 cm.	10 - 40	May be <100
Hygric (7a)[2]	66	Hygric aerated: Water removed slowly enough to keep the soil wet for most of the growing season; mottling present within 50 cm.	16 - 40	30-100
Hygric (7r)[2]	24W	Hygric reduced: Water removed slowly enough to keep the soil wet for most of the growing season; >50% gley within 50 cm.	16 - 40	30-100
Subhydric (8)	0W	Water removed slowly enough to keep the water table at or near surface for most of the year; organic and gleyed mineral soils; permanent seepage < 30 cm below soil surface.	> 40	0-30
Hydric (9)	0W	Water removed so slowly that the water table is at or above the soil surface all year; organic and gleyed mineral soils.	> 40	0+

[1] Circle the appropriate SMR index and subclass based on soil and landscape description, surface organic thickness, and water table depth.

[2] Subhygric and hygric moisture reqimes are not to be applied to reclaimed soils at this time.

Note: additional indicators can be found in Table 9.

AWHC Calculation (water table >100 cm; no gleying)

Horizon Designation	Texture	Horizon Thickness (cm)	Multiplier	AWHC (mm)	% coarse fragments adjustment (vol.)	% coarse fragments adjustment (mm)	AWHC (mm)
Ae	L	15	1.5	22.5	<2	-	23
Bt	C	35	1.6	56	<2	-	56
BC	C	50	1.6	80	<2	-	80
					Profile AWHC =	Σ	159 (i)

Layering modifiers

Check box if soil profile information above meets the criteria for one of the layering modifiers for a 15 mm upgrade.

Impermeable layer	☐	-
Coarse over fine material stratification	☐	-
Fine over coarse material stratification	☐	-
Layering effect =		0 (ii)

Subclass 'O' where ≥15 cm O horizon beginning at 0 cm (reclaimed soils).

Subclass 'P' where % coarse fragments adjustment is ≥30 mm

Subclass 'Z' where R, KC, IMP, or i horizon occupies ≥30 cm of the profile.

Landscape Modifiers (≥10% slopes)

Aspect (degree range)	Crest 1	Upper 2	Mid 3	Lower 4		
NW-NE (316-45)	-15	0	+15	+15		
NE-SE (46-135)	-15	-15	0	0		
SE-SW (136-225)	-15	-30	-30	-30		
SW-NW (226-315)	-15	-15	0	0	**0**	(iii)

Circle applicable slope and aspect combination; toe, depression and level = 0.

Adjusted AWHC

Adjusted AWHC = (i) + (ii) + (iii) = 159 (i) + 0 (ii) + 0 (iii) = 159

Moisture regime	SMR Index and Subclass	Adjusted AWHC (mm 100cm^{-1})
Very xeric (1)	10X	< 56
Xeric (2)	24X	56 – 85
Subxeric (3)	38X	86 – 115
Submesic (4)	52	116 – 145
Mesic (5)	66	146 – 175

SMR, SMR index and Subclass

Soil Moisture Regime	**Mesic**
SMR Index	**66**
Subclass	**-**

SOIL NUTRIENT REGIME INDEX AND SUBCLASS DETERMINATION

Total C, N and C:N

Horizon Designation	Depth (cm)	Horizon thickness (cm)	Bulk density (Mg m^3)	TOC (%)	TOC (Mg ha^{-1})	Total Nitrogen (%)	Total Nitrogen (Mg ha^{-1})
LFH	12 – 0	12	0.15	27	**49**	1.06	**1.9**
Ae	0-15	15	1.65	0.52	**13**	0.02	**0.5**
Bt	15-20	5	1.60	0.25	**2**	0.01	**0.1**
				Σ	**64**		**Σ 2.5**
				C:N	**= 64/2.5 = 26**		

Nutrient retention rating

Horizon Designation	Depth (cm)	Horizon thickness (cm)	Texture	Assigned rating	Weighted average calculation
LFH	12 – 0	12	-	-	
Ae	0-15	15	L	3	TS = 15/20 x (3) + 5/20 x (3) = 3
Bt	15-50	35	C	3	US = 30/30 x (3) = 3
					Σ = 3 + 3 = 6

Cumulative rating

Parameter		Value					Rating
Organic Carbon	(Mg ha^{-1})	64					4
Total Nitrogen	(Mg ha^{-1})	2.5					4
C/N ratio		26					4
Nutrient Retention[1]		TS	3	US	3		6

[1] Weighted average calculation may be required.

Cumulative rating	Σ	18
Soil Nutrient Regime Index and Subclass	SNR	15

Base rating

Base Rating = SMR Index + SNR Index = SMR Index (66) + SNR index (15) = **81** (a)

Subclass(es) = _____

LIMITING FACTOR DEDUCTIONS

Weighted average calculations must be performed as required.

Topsoil Adjustment (0-20 cm)

Factor		Value	Deduction	Subclass
Structure/Consistence		0-15cm=(75%)(0% ded.)=0% 15-20cm=(25%)(0% ded.)=0%	0 %	D
Reaction	pH	0-15cm=(75%)(15% ded.)=11% 15-20cm=(25%)(15% ded.)=4%	**15 %**	V
Salinity	EC (dS m^{-1})	0.3	0 %	N
Sodicity	SAR	1	0 %	Y

TS deduction (b) **(b)** = (most limiting of D, V, N, Y%)(a)

(b) = (15)(a) = **12.2** **(b)**

Interim soil rating (c) **(c)** = (a) – (b)

(c) = (81) - (12.2) = 68.8 **(c)**

Upper Subsoil Adjustment (20-50 cm)

Factor		Value	Deduction	Subclass
Structure/Consistence		20-50cm=(100%)(0% ded.)=0%	0 %	D
Reaction	pH	5.0	**15 %**	V
Salinity	EC (dS m^{-1})	0.3	0 %	N
Sodicity	SAR	1	0 %	Y

US deduction (d) **(d)** = (most limiting of D, V, N, Y%)(c) (0.67)

(d) = (15)(68.8)(0.67) = **6.9** **(d)**

Lower Subsoil Adjustment (50-100 cm)

Factor		Value	Deduction	Subclass
Structure/Consistence		50-100cm=(100%)(15%ded)=10%	**15 %**	D
Reaction	pH	6.6	0 %	V
Salinity	EC (dS m^{-1})	0.35	0 %	N
Sodicity	SAR	1.6	0 %	Y

LS deduction (e) **(e)** = (most limiting of D, V, N, Y%)(c) (0.33)

(e) = (15)(68.8)(0.33) = **3.4** **(e)**

Final Land rating = (a) – (b) – (d) – (e)

Final Land Rating = (**81**) – (**12.2**) – (**6.9**) – (**3.4**) = **58.5**

Land capability rating ranges	Land capability class
81-100	Class 1
61-80	Class 2
41-60	Class 3
21-40	Class 4
0-20	Class 5

Land capability rating:	**59**
Land capability class:	**3**
Subclass(es):	

Site and Soil Description Form

Location/Site	*2*	Assessment date	***May 24, 2006***	
Map Unit/Soil Series	***Mildred***	Assessor(s)	***CEMA***	
Soil Classification	***Eluviated Dystric Brunisol***	Ecosite	a [*b*] c d e f g h i j k l	
Parent Material	Genetic: ***Fluvial*** Expression: ***Undulating***	Type	Natural ☐ ☑ Reclaimed ☐	
Drainage	VR [*R*] W MW I P VP	Site Index and Species	Species: ***Jack pine*** Height: ***15 m*** Age: ***45 years***	Site Index: ***17***
Soil Moisture Regime	1 2 [*3*] 4 5 6 7a 7b 8 9	Stand Quality	High Moderate [*Low*] Non-Productive	
Soil Nutrient Regime	[*P*] M R	Compaction	[*None*] Sli Mod Sev V.Sev Ext	
Topography	Percent: ***5*** Position: ***Midslope (C)*** Aspect: ***180° (South)***	Notes		
Coarse Fragments (% vol. to 1 m)	Gravel: ***<2%*** Stones: ***0%***			
Depth to water table (cm)	***> 100 cm***			
Samples	***4***			

Horizon	Depth	Color	Texture	Structure			Consistence	Mottles			Impermeable	Coarse Fragments (%)	Sample ID
				Grade	Size (mm)	Kind		Abundance	Size	Contrast			
LF	5-0	10YR 2/1m	-	-	-	-	-	-	-	-	-	0	2-LF
Ae	0-11	10YR 5/3m	S	-	-	SG	Loose	-	-	-	-	<2	2-Ae
Bm	11-44	7.5YR 5/8m	LS	-	-	SG	Loose	-	-	-	-	<2	2-Bm
BC	44-71	10YR 5/6m	LS	-	-	SG	Loose	-	-	-	-	<2	2-BC/C
C	71-100	10YR 5/3m	LS	-	-	SG	Loose	-	-	-	-	<2	2-BC/C

Analytical results

Site Id	Sample ID	Thickness (cm)	TOC (%)	Total nitrogen (%)	Bulk density (Mg m^{-3})	Clay (%)	Sand (%)	Silt (%)	Texture	pH (H_2O)	EC (dS m^{-1})	SAR
2	2-LFH	5	8.14	0.37	0.2	-	-	-	-	5.0	-	-
2	2 – Ae	11	1.05	0.03	1.3	4	92	4	S	4.3	0.1	0.2
2	2 – Bm	33	0.5	0.02	1.47	3	93	4	S	4.8	0.1	0.2
2	2 – BC/C	56	-	-	-	3	90	7	S	5.4	0.15	0.3

LAND CAPABILITY WORKSHEET

SOIL MOISTURE REGIME INDEX AND SUBCLASS DETERMINATION

Water table ≤100 cm[1]

Moisture regime	SMR Index and Subclass	Description	Surface organic thickness (cm)	Water table depth (cm)
Subhygric (6)[2]	80	Water removed slowly enough to keep the soil wet for a significant part of the growing season; some temporary seepage and possible mottling below 20 cm.	10 - 40	May be <100
Hygric (7a)[2]	66	Hygric aerated: Water removed slowly enough to keep the soil wet for most of the growing season; mottling present within 50 cm.	16 - 40	30-100
Hygric (7r)[2]	24W	Hygric reduced: Water removed slowly enough to keep the soil wet for most of the growing season; >50% gley within 50 cm.	16 - 40	30-100
Subhydric (8)	0W	Water removed slowly enough to keep the water table at or near surface for most of the year; organic and gleyed mineral soils; permanent seepage < 30 cm below soil surface.	> 40	0-30
Hydric (9)	0W	Water removed so slowly that the water table is at or above the soil surface all year; organic and gleyed mineral soils.	> 40	0+

[1] Circle the appropriate SMR index and subclass based on soil and landscape description, surface organic thickness, and water table depth.

[2] Subhygric and hygric moisture reqimes are not to be applied to reclaimed soils at this time.

Note: additional indicators can be found in Table 9.

AWHC Calculation (water table >100 cm; no gleying)

Horizon Designation	Texture	Horizon Thickness (cm)	Multiplier	AWHC (mm)	% coarse fragments adjustment (vol.)	(mm)	AWHC (mm)
Ae	S	11	0.8	8.8	<2	-	8.8
Bm	S	33	0.8	26.4	<2	-	26.4
BC/C	S	56	0.8	23.2	<2	-	44.8
						Profile AWHC = Σ	80 (i)

Layering modifiers

Check box if soil profile information above meets the criteria for one of the layering modifiers for a 15 mm upgrade.

Impermeable layer	☐	-
Coarse over fine material stratification	☐	-
Fine over coarse material stratification	☐	-
Layering effect =		0 (ii)

Subclass 'O' where ≥15 cm O horizon beginning at 0 cm (reclaimed soils).

Subclass 'P' where % coarse fragments adjustment is ≥30 mm

Subclass 'Z' where R, KC, IMP, or i horizon occupies ≥30 cm of the profile.

Landscape Modifiers (≥10% slopes)

Aspect (degree range)	Crest 1	Upper 2	Mid 3	Lower 4		
NW-NE (316-45)	-15	0	+15	+15		
NE-SE (46-135)	-15	-15	0	0		
SE-SW (136-225)	-15	-30	-30	-30		
SW-NW (226-315)	-15	-15	0	0	**0**	(iii)

Circle applicable slope and aspect combination; toe, depression and level = 0.

Adjusted AWHC

Adjusted AWHC = (i) + (ii) + (iii) = 80 (i) + 0 (ii) + 0 (iii) = 80

Moisture regime	SMR Index and Subclass	Adjusted AWHC (mm 100cm^{-1})
Very xeric (1)	10X	< 56
Xeric (2)	24X	56 – 85
Subxeric (3)	38X	86 – 115
Submesic (4)	52	116 – 145
Mesic (5)	66	146 – 175

SMR, SMR index and Subclass

Soil Moisture Regime	**Xeric**
SMR Index	**24**
Subclass	**X**

SOIL NUTRIENT REGIME INDEX AND SUBCLASS DETERMINATION

Total C, N and C:N

Horizon Designation	Depth (cm)	Horizon thickness (cm)	Bulk density (Mg m^{3})	TOC (%)	TOC (Mg ha^{-1})	Total Nitrogen (%)	Total Nitrogen (Mg ha^{-1})
LFH	5-0	5	0.2	8.14	**8.1**	0.37	**0.37**
Ae	0-11	11	1.3	1.05	**15.0**	0.03	**0.43**
Bm	11-20	9	1.47	0.5	**6.6**	0.02	**0.26**
				Σ	**30**	**Σ**	**1.1**
				C:N	**= 30/1.1 = 28**		

Nutrient retention rating

Horizon Designation	Depth (cm)	Horizon thickness (cm)	Texture	Assigned rating	Weighted average calculation
LFH	5-0	5	-	-	
Ae	0-11	11	S	0	TS = 11/20 x (0) + 9/20 x (0) = 0
Bt	11-44	33	S	0	US = 24/30 x (0) + 6/30 x (0) = 0
BC	44-50	6	S	0	Σ = 0 + 0 = 0

Cumulative rating

Parameter		Value					Rating
Organic Carbon	($Mg\ ha^{-1}$)	30					2
Total Nitrogen	($Mg\ ha^{-1}$)	1.1					2
C/N ratio		28					4
Nutrient Retention[1]		TS	0	US	0		0

[1] Weighted average calculation may be required.

Cumulative rating	Σ	8
Soil Nutrient Regime Index and Subclass	SNR	0F

Base rating

Base Rating = SMR Index + SNR Index = SMR Index (24) + SNR index (0) = **24** (a)

Subclass(es) = X F

LIMITING FACTOR DEDUCTIONS

Weighted average calculations must be performed as required.

Topsoil Adjustment (0-20 cm)

Factor		Value	Deduction	Subclass
Structure/Consistence		0-20cm=(100%)(0% ded.)=0%	0 %	D
Reaction	pH	0-11cm=(55%)(40% ded.)=11% 11-20cm=(45%)(15% ded.)=4%	**29 %**	V
Salinity	EC ($dS\ m^{-1}$)	0.1	0 %	N
Sodicity	SAR	0.2	0 %	Y

TS deduction (b) **(b)** = (most limiting of D, V, N, Y%)(a)

(b) = (29)**(a)** = **7.0** **(b)**

Interim soil rating (c) **(c) = (a) – (b)**

(c) = (24) - (7.0) = 17 (c)

Upper Subsoil Adjustment (20-50 cm)

Factor		Value	Deduction	Subclass
Structure/Consistence		20-44cm=(80%)(0% ded.)=0% 44-50cm=(20%)(0% ded.)=0%	0 %	D
Reaction	pH	20-44cm=(80%)(15% ded.)=12% 44-50cm=(20%)(0% ded.)=0%	**12 %**	V
Salinity	EC (dS m^{-1})	0.1	0 %	N
Sodicity	SAR	0.2	0 %	Y

US deduction (d) **(d) = (most limiting of D, V, N, Y%)(c) (0.67)**

(d) = (12)(17)(0.67) = 1.4 (d)

Lower Subsoil Adjustment (50-100 cm)

Factor		Value	Deduction	Subclass
Structure/Consistence		50-100cm=(100%)(10%ded)=10%	0 %	D
Reaction	pH	5.4	0 %	V
Salinity	EC (dS m^{-1})	0.15	0 %	N
Sodicity	SAR	0.3	0 %	Y

LS deduction (e) **(e) = (most limiting of D, V, N, Y%)(c) (0.33)**

(e) = (0)(17)(0.33) = 0 (e)

Final Land rating = (a) – (b) – (d) – (e)

Final Land Rating = (**24**) – (**7.0**) – (**1.4**) – (**0**) = **15.6**

Land capability rating ranges	Land capability class
81-100	Class 1
61-80	Class 2
41-60	Class 3
21-40	Class 4
0-20	Class 5

Land capability rating:	**15.6**
Land capability class:	**5**
Subclass(es):	**FVX**

Site and Soil Description Form

Location/Site	*3*	Assessment date	***May 24, 2006***
Map Unit/Soil Series	***McMurray***	Assessor(s)	***CEMA***
Soil Classification	***Gleyed Humic Regosol***	Ecosite	a b c d [e] f g h i j k l
Parent Material	Genetic: ***Fluvial / bedrock within 100 cm*** Expression: ***Terrace***	Type	Natural ☐ [☑] Reclaimed ☐
Drainage	VR R W MW [*I*] P VP	Site Index and Species	Species: ***Trembling Aspen*** Height: ***25 m*** Age: ***67 years*** Site Index: ***22***
Soil Moisture Regime	1 2 3 4 5 [*6*] 7a 7b 8 9	Stand Quality	[***High***] Moderate Low Non-Productive
Soil Nutrient Regime	P M [*R*]	Compaction	[***None***] Sli Mod Sev V.Sev Ext
Topography	Percent: ***5*** Position: ***Lower (D)*** Aspect: ***90° (East)***	Notes: Consolidated Bedrock at 74 cm	
Coarse Fragments (% vol. to 1 m)	Gravel: ***<2%*** Stones: ***0%***		
Depth to water table (cm)	***74 cm***		
Samples	***5***		

Horizon	Depth	Color	Texture	Structure			Consistence	Mottles			Impermeable	Coarse Fragments (%)	Sample ID
				Grade	Size (mm)	Kind		Abundance	Size	Contrast			
LFH	6-0	10YR 2/1m	-	-	-	-	-	-	-	-	-	0	3-LFH
Ahj	0-24	10YR 5/2m	SiCL	W	2-5	GR	Friable	-	-	-	-	<2	3-Ahj
Btjgj	24-61	10YR 4/4m	SiCL	-	5-10	SBK	Friable	Common	Fine	Distinct	-	<2	3-Btjgj
IIBCg	61-74	7.5YR 4/4m	CL	-	<20	MA	Friable	Many	Fine	Distinct	-	<2	3-IIBCg
R	74-100	10YR 6/2m	-	-	>100	MA	Ext. hard	-	-	-	Yes	100	-

Analytical results

Site Id	Sample ID	Thickness (cm)	TOC (%)	Total nitrogen (%)	Bulk density (Mg m^{-3})	Clay (%)	Sand (%)	Silt (%)	Texture	pH (H_2O)	EC (dS m^{-1})	SAR
3	3-LFH	6	32.2	1.14	0.15	-	-	-	-	6.8	-	-
3	3 – Ahj	24	8.4	0.45	0.51	27	19	54	SiCL	7.3	0.4	0.5
3	3 – Btjgj	37	-	-	1.19	34	14	52	SiCL	7.5	0.4	0.5
3	3 – IIBCg	13	-	-	1.50	30	36	34	CL	7.6	0.63	0.7
3	3 – R	26	-	-	-	-	-	-	-	7.6	0.63	0.7

LAND CAPABILITY WORKSHEET

SOIL MOISTURE REGIME INDEX AND SUBCLASS DETERMINATION

Water table ≤100 cm[1]

Moisture regime	SMR Index and Subclass	Description	Surface organic thickness (cm)	Water table depth (cm)
Subhygric (6)[2]	***80***	Water removed slowly enough to keep the soil wet for a significant part of the growing season; some temporary seepage and possible mottling below 20 cm.	10 - 40	May be <100
Hygric (7a)[2]	66	Hygric aerated: Water removed slowly enough to keep the soil wet for most of the growing season; mottling present within 50 cm.	16 - 40	30-100
Hygric (7r)[2]	24W	Hygric reduced: Water removed slowly enough to keep the soil wet for most of the growing season; >50% gley within 50 cm.	16 - 40	30-100
Subhydric (8)	0W	Water removed slowly enough to keep the water table at or near surface for most of the year; organic and gleyed mineral soils; permanent seepage < 30 cm below soil surface.	> 40	0-30
Hydric (9)	0W	Water removed so slowly that the water table is at or above the soil surface all year; organic and gleyed mineral soils.	> 40	0+

[1] Circle the appropriate SMR index and subclass based on soil and landscape description, surface organic thickness, and water table depth.

[2] Subhygric and hygric moisture reqimes are not to be applied to reclaimed soils at this time.

Note: additional indicators can be found in Table 9.

AWHC Calculation (water table >100 cm; no gleying)

Horizon Designation	Texture	Horizon Thickness (cm)	Multiplier	AWHC (mm)	% coarse fragments adjustment (vol.)	% coarse fragments adjustment (mm)	AWHC (mm)

Profile AWHC = Σ _____ (i)

Layering modifiers

Check box if soil profile information above meets the criteria for one of the layering modifiers for a 15 mm upgrade.

Impermeable layer	☐	-
Coarse over fine material stratification	☐	-
Fine over coarse material stratification	☐	-
Layering effect =		**0** (ii)

Subclass 'O' where ≥15 cm O horizon beginning at 0 cm (reclaimed soils).

Subclass 'P' where % coarse fragments adjustment is ≥30 mm

Subclass 'Z' where R, KC, IMP, or i horizon occupies ≥30 cm of the profile.

Landscape Modifiers (≥10% slopes)

Aspect (degree range)	Crest 1	Upper 2	Mid 3	Lower 4		
NW-NE (316-45)	-15	0	+15	+15		
NE-SE (46-135)	-15	-15	0	0		
SE-SW (136-225)	-15	-30	-30	-30		
SW-NW (226-315)	-15	-15	0	0	**0**	(iii)

Circle applicable slope and aspect combination; toe, depression and level = 0.

Adjusted AWHC

Adjusted AWHC = (i) + (ii) + (iii) = 80 (i) + 0 (ii) + 0 (iii) = 80

Moisture regime	SMR Index and Subclass	Adjusted AWHC (mm 100cm^{-1})
Very xeric (1)	10X	< 56
Xeric (2)	24X	56 – 85
Subxeric (3)	38X	86 – 115
Submesic (4)	52	116 – 145
Mesic (5)	66	146 – 175

SMR, SMR index and Subclass

Soil Moisture Regime	**Subhygric**
SMR Index	**80**
Subclass	

SOIL NUTRIENT REGIME INDEX AND SUBCLASS DETERMINATION

Total C, N and C:N

Horizon Designation	Depth (cm)	Horizon thickness (cm)	Bulk density (Mg m^3)	TOC (%)	TOC (Mg ha^{-1})	Total Nitrogen (%)	Total Nitrogen (Mg ha^{-1})
LFH	6-0	6	0.15	32.3	**29.1**	1.14	**1.0**
Ahj	0-24	24	0.51	8.4	**85.5**	0.45	**4.6**
Btjgj	24-61	37	1.19	-	-	-	-
IIBCg	61-74	13	1.50	-	-	-	-
				Σ	**115**	**Σ**	**5.6**
				C:N	**= 115/5.6 = 21**		

Nutrient retention rating

Horizon Designation	Depth (cm)	Horizon thickness (cm)	Texture	Assigned rating	Weighted average calculation
LFH	6-0	6	-	-	
Ahj	0-24	24	SiCL	3	TS = 20/20 x (3) = 3
Btjgj	24-50	26	SiCL	3	US = 4/30 x (3) + 26/30 x (3) = 3
					Σ = 3 + 3 = 6

Cumulative rating

Parameter		Value					Rating
Organic Carbon	(Mg ha^{-1})	115					6
Total Nitrogen	(Mg ha^{-1})	5.6					6
C/N ratio		21					4
Nutrient Retention[1]		TS	3	US	3		6

[1] Weighted average calculation may be required.

Cumulative rating	Σ	22
Soil Nutrient Regime Index and Subclass	SNR	20

Base rating

Base Rating = SMR Index + SNR Index = SMR Index (80) + SNR index (20) = **100** (a)

Subclass(es) = _____ _____

LIMITING FACTOR DEDUCTIONS

Weighted average calculations must be performed as required.

Topsoil Adjustment (0-20 cm)

Factor		Value	Deduction	Subclass
Structure/Consistence		0-20cm=(100%)(0% ded.)=0%	0 %	D
Reaction	pH	7.3	**10 %**	V
Salinity	EC (dS m^{-1})	0.4	0 %	N
Sodicity	SAR	0.5	0 %	Y

TS deduction (b) **(b)** = (most limiting of D, V, N, Y%)(a)

(b) = (**10**)(a) = **10** **(b)**

Interim soil rating (c) **(c)** = (a) – (b)

(c) = (100) - (10) = 90 **(c)**

Upper Subsoil Adjustment (20-50 cm)

Factor		Value	Deduction	Subclass
Structure/Consistence		20-50cm=(100%)(0% ded.)=0%	0 %	D
Reaction	pH	7.5	10 %	V
Salinity	EC (dS m^{-1})	0.4	0 %	N
Sodicity	SAR	0.5	0 %	Y

US deduction (d) **(d)** = (most limiting of D, V, N, Y%)(c) (0.67)

(d) = (10)(90)(0.67) = **6.0** **(d)**

Lower Subsoil Adjustment (50-100 cm)

Factor		Value	Deduction	Subclass
Structure/Consistence		50-74cm=(48%)(0%ded)=0% 74-100cm=(52%)(80%ded)=42%	42 %	D
Reaction	pH	50-61cm=(22%)(10%ded)=2.2% 61-100cm=(78%)(20%ded)=15.6%	17.8 %	V
Salinity	EC (dS m^{-1})	0.63	0 %	N
Sodicity	SAR	0.7	0 %	Y

LS deduction (e) **(e)** = (most limiting of D, V, N, Y%)(c) (0.33)

(e) = (42)(90)(0.33) = **12.4** **(e)**

Final Land rating = (a) – (b) – (d) – (e)

Final Land Rating = (**100**) – (**10**) – (**6.0**) – (**12.4**) = **71.6**

Land capability rating ranges	Land capability class
81-100	Class 1
61-80	Class 2
41-60	Class 3
21-40	Class 4
0-20	Class 5

Land capability rating:	**72**
Land capability class:	**2**
Subclass(es):	**D**

Site and Soil Description Form

Location/Site	*4*	Assessment date	*May 24, 2006*	
Map Unit/Soil Series	*Algar*	Assessor(s)	*CEMA*	
Soil Classification	*Orthic Gleysol*	Ecosite	a b c [d] e f g h i j k l	
Parent Material	Genetic: *Glaciolacustrine* Expression: *Level*	Type	Natural ☐☑ Reclaimed ☐	
Drainage	VR R W MW I [P] VP	Site Index and Species	Species: *White Spruce* Height: *23 m* Age: *69 years*	Site Index: *18*
Soil Moisture Regime	1 2 3 4 5 6 [7a] 7b 8 9	Stand Quality	High [*Moderate*] Low Non-Productive	
Soil Nutrient Regime	P [*M*] R	Compaction	[*None*] Sli Mod Sev V.Sev Ext	
Topography	Percent: *1* Position: *Level (G)* Aspect: *None*	Notes: Water table at 75 cm		
Coarse Fragments (% vol. to 1 m)	Gravel: *<2%* Stones: *0%*			
Depth to water table (cm)	*75*			
Samples	*4*			

Horizon	Depth	Color	Texture	Structure			Consistence	Mottles			Impermeable	Coarse Fragments (%)	Sample ID
				Grade	Size (mm)	Kind		Abundance	Size	Contrast			
LFH	2-0	10YR 2/1m	-	-	-	-	-	-	-	-	-	0	4-LFH/Om
Om	0-18	10YR 2/1m	-	-	-	-	-	-	-	-	-	0	4-LFH/Om
Ahe	18-20	10YR 4/3m	L	W	<2	GR	Friable	-	-	-	-	<2	4-Ahe
Bg	20-50	10YR 4/2m	C	M	10-20	SBK	Firm	Many	Coarse	Distinct	-	<2	4-Bg
Cg	50-100	10YR 5/1m	CL		50-100	MA	Firm	Many	Coarse	Distinct	-	<2	4-Cg

Analytical results

Site Id	Sample ID	Thickness (cm)	TOC (%)	Total nitrogen (%)	Bulk density ($Mg\ m^{-3}$)	Clay (%)	Sand (%)	Silt (%)	Texture	pH (H_2O)	EC ($dS\ m^{-1}$)	SAR
4	4-LFH/Om	20	41.4	1.11	0.1	-	-	-	-	5.1	-	-
4	4 – Ahe	2	1.37	0.06	1.14	15	44	41	L	4.6	0.1	0.3
4	4 – Bg	48	1	0.04	1.44	49	18	33	C	5.4	0.1	0.3
4	4 – Cg	46	-	-	1.58	35	36	29	CL	5.4	0.22	0.4

LAND CAPABILITY WORKSHEET

SOIL MOISTURE REGIME INDEX AND SUBCLASS DETERMINATION

Water table ≤100 cm[1]

Moisture regime	SMR Index and Subclass	Description	Surface organic thickness (cm)	Water table depth (cm)
Subhygric (6)[2]	80	Water removed slowly enough to keep the soil wet for a significant part of the growing season; some temporary seepage and possible mottling below 20 cm.	10 - 40	May be <100
Hygric (7a)[2]	***66***	Hygric aerated: Water removed slowly enough to keep the soil wet for most of the growing season; mottling present within 50 cm.	16 - 40	30-100
Hygric (7r)[2]	24W	Hygric reduced: Water removed slowly enough to keep the soil wet for most of the growing season; >50% gley within 50 cm.	16 - 40	30-100
Subhydric (8)	0W	Water removed slowly enough to keep the water table at or near surface for most of the year; organic and gleyed mineral soils; permanent seepage < 30 cm below soil surface.	> 40	0-30
Hydric (9)	0W	Water removed so slowly that the water table is at or above the soil surface all year; organic and gleyed mineral soils.	> 40	0+

[1] Circle the appropriate SMR index and subclass based on soil and landscape description, surface organic thickness, and water table depth.

[2] Subhygric and hygric moisture regimes are not to be applied to reclaimed soils at this time.

Note: additional indicators can be found in Table 9.

AWHC Calculation (water table >100 cm; no gleying)

Horizon Designation	Texture	Horizon Thickness (cm)	Multiplier	AWHC (mm)	% coarse fragments adjustment (vol.)	(mm)	AWHC (mm)

Profile AWHC = Σ _____ (i)

Layering modifiers

Check box if soil profile information above meets the criteria for one of the layering modifiers for a 15 mm upgrade.

Impermeable layer	☐	-
Coarse over fine material stratification	☐	-
Fine over coarse material stratification	☐	-
Layering effect =		**0** (ii)

Subclass 'O' where ≥15 cm O horizon beginning at 0 cm (reclaimed soils).

Subclass 'P' where % coarse fragments adjustment is ≥30 mm

Subclass 'Z' where R, KC, IMP, or i horizon occupies ≥30 cm of the profile.

Landscape Modifiers (≥10% slopes)

Aspect (degree range)	Crest 1	Upper 2	Mid 3	Lower 4		
NW-NE (316-45)	-15	0	+15	+15		
NE-SE (46-135)	-15	-15	0	0		
SE-SW (136-225)	-15	-30	-30	-30		
SW-NW (226-315)	-15	-15	0	0	**0**	(iii)

Circle applicable slope and aspect combination; toe, depression and level = 0.

Adjusted AWHC

Adjusted AWHC = (i) + (ii) + (iii) = 66 (i) + 0 (ii) + 0 (iii) = 66

Moisture regime	SMR Index and Subclass	Adjusted AWHC (mm 100cm^{-1})
Very xeric (1)	10X	< 56
Xeric (2)	24X	56 – 85
Subxeric (3)	38X	86 – 115
Submesic (4)	52	116 – 145
Mesic (5)	66	146 – 175

SMR, SMR index and Subclass

Soil Moisture Regime	**Hygric**
SMR Index	**66**
Subclass	

SOIL NUTRIENT REGIME INDEX AND SUBCLASS DETERMINATION

Total C, N and C:N

Horizon Designation	Depth (cm)	Horizon thickness (cm)	Bulk density (Mg m^{3})	TOC (%)		TOC (Mg ha^{-1})	Total Nitrogen (%)		Total Nitrogen (Mg ha^{-1})
LFH/Om	2-0-18	20	0.1	41.4		**82.8**	1.11		**2.2**
Ahe	1-20	2	1.14	1.4		**3.1**	0.06		**0.1**
					Σ	**85.9**		Σ	**2.3**
					C:N	**= 86/2.3 = 37**			

Nutrient retention rating

Horizon Designation	Depth (cm)	Horizon thickness (cm)	Texture	Assigned rating	Weighted average calculation
LFH/Om	2-0-18	20	-	-	
Ahe	18-20	2	L	2	TS = 18/20 x (0) + 2/20 x (3) + 8/20 x (1) = 0.3
Bg	20-50	30	C	1	US = 30/30 x (1) = 3
					Σ = 0 + 3 = 3

Cumulative rating

Parameter		Value				Rating
Organic Carbon	(Mg ha^{-1})	86				6
Total Nitrogen	(Mg ha^{-1})	2.3				4
C/N ratio		37				2
Nutrient Retention[1]		TS	0	US	3	3

[1] Weighted average calculation may be required.

Cumulative rating	Σ	15
Soil Nutrient Regime Index and Subclass	SNR	10

Base rating

Base Rating = SMR Index + SNR Index = SMR Index (66) + SNR index (10) = **76** (a)

Subclass(es) =

LIMITING FACTOR DEDUCTIONS

Weighted average calculations must be performed as required.

Topsoil Adjustment (0-20 cm)

Factor		Value	Deduction	Subclass
Structure/Consistence		18cm=(90%)(0% ded.)=0% 2cm=(10%)(0% ded.)=0%	0 %	D
Reaction	pH	18cm=(90%)(0% ded.)=0% 2cm=(10%)(15% ded.)=0%	**1.5 %**	V
Salinity	EC (dS m^{-1})	0.1	0 %	N
Sodicity	SAR	0.3	0 %	Y

TS deduction (b) **(b)** = (most limiting of D, V, N, Y%)(a)

(b) = (**2**)(a) = **1.1** **(b)**

Interim soil rating (c) **(c) = (a) – (b)**

(c) = (76) - (1.1) = 74.9 (c)

Upper Subsoil Adjustment (20-50 cm)

Factor		Value	Deduction	Subclass
Structure/Consistence		20-50cm=(100%)(10% ded.)=10%	**10 %**	D
Reaction	pH	5.4	0 %	V
Salinity	EC (dS m^{-1})	0.1	0 %	N
Sodicity	SAR	0.3	0 %	Y

US deduction (d) **(d) = (most limiting of D, V, N, Y%)(c) (0.67)**

(d) = (10)(74.9)(0.67) = 5.0 (d)

Lower Subsoil Adjustment (50-100 cm)

Factor		Value	Deduction	Subclass
Structure/Consistence		50-100cm=(100%)(0%ded)=30%	**30 %**	D
Reaction	pH	5.4	0 %	V
Salinity	EC (dS m^{-1})	0.22	0 %	N
Sodicity	SAR	0.4	0 %	Y

LS deduction (e) **(e) = (most limiting of D, V, N, Y%)(c) (0.33)**

(e) = (30)(74.9)(0.33) = 7.4 (e)

Final Land rating = (a) – (b) – (d) – (e)

Final Land Rating = (76) – (1.1) – (5.0) – (7.4) = 62.5

Land capability rating ranges	Land capability class
81-100	Class 1
61-80	Class 2
41-60	Class 3
21-40	Class 4
0-20	Class 5

Land capability rating:	**63**
Land capability class:	**2**
Subclass(es):	**D**

Site and Soil Description Form

Location/Site	*5*	Assessment date	***May 24, 2006***
Map Unit/Soil Series	***Muskeg***	Assessor(s)	***CEMA***
Soil Classification	***Terric Mesisol***	Ecosite	a b c d e f g h **i** j k l
Parent Material	Genetic: ***Organic / Mineral*** Expression: ***Level***	Type	Natural ☑ Reclaimed ☐
Drainage	VR R W MW I P **VP**	Site Index and Species	Species: ***Black Spruce*** Height: ***<5 m*** Age: ***N/A*** — Site Index: ***N/A***
Soil Moisture Regime	1 2 3 4 5 6 7a 7b **8** 9	Stand Quality	High Moderate Low ***Non-Productive***
Soil Nutrient Regime	P **M** R	Compaction	***None*** Sli Mod Sev V.Sev Ext
Topography	Percent: ***1*** Position: ***Level (G)*** Aspect: ***None***	Notes: Water table at 20 cm	
Coarse Fragments (% vol. to 1 m)	Gravel: ***<2%*** Stones: ***0%***		
Depth to water table (cm)	***20***		
Samples	***3***		

Horizon	Depth	Color	Texture	Structure			Consistence	Mottles			Impermeable	Coarse Fragments (%)	Sample ID
				Grade	Size (mm)	Kind		Abundance	Size	Contrast			
Om	0-20	10YR 2/1m	-	-	-	-	-	-	-	-	-	0	5- Om1
Om	20-60	10YR 2/1m	-	-	-	-	-	-	-	-	-	0	5- Om2
Bg	60-100	10YR 4/3m	CL	W	10-20	SBK	Very sticky	Many	Coarse	Distinct	-	<2	5-Bg

Analytical results

Site Id	Sample ID	Thickness (cm)	TOC (%)	Total nitrogen (%)	Bulk density (Mg m^{-3})	Clay (%)	Sand (%)	Silt (%)	Texture	pH (H_2O)	EC (dS m^{-1})	SAR
5	5-Om1	20	30	1	0.2	-	-	-	-	4.5	0.46	0.17
5	5-Om2	40	-	-	-	-	-	-	-	5.0	0.23	0.25
5	5-Bg	40	-	-	-	30	30	40	CL	7.0	0.47	0.12

LAND CAPABILITY WORKSHEET

SOIL MOISTURE REGIME INDEX AND SUBCLASS DETERMINATION

Water table ≤100 cm[1]

Moisture regime	SMR Index and Subclass	Description	Surface organic thickness (cm)	Water table depth (cm)
Subhygric (6)[2]	80	Water removed slowly enough to keep the soil wet for a significant part of the growing season; some temporary seepage and possible mottling below 20 cm.	10 - 40	May be <100
Hygric (7a)[2]	66	Hygric aerated: Water removed slowly enough to keep the soil wet for most of the growing season; mottling present within 50 cm.	16 - 40	30-100
Hygric (7r)[2]	24W	Hygric reduced: Water removed slowly enough to keep the soil wet for most of the growing season; >50% gley within 50 cm.	16 - 40	30-100
Subhydric (8)	***0W***	Water removed slowly enough to keep the water table at or near surface for most of the year; organic and gleyed mineral soils; permanent seepage < 30 cm below soil surface.	> 40	0-30
Hydric (9)	0W	Water removed so slowly that the water table is at or above the soil surface all year; organic and gleyed mineral soils.	> 40	0+

[1] Circle the appropriate SMR index and subclass based on soil and landscape description, surface organic thickness, and water table depth.

[2] Subhygric and hygric moisture regimes are not to be applied to reclaimed soils at this time.

Note: additional indicators can be found in Table 9.

AWHC Calculation (water table >100 cm; no gleying)

Horizon Designation	Texture	Horizon Thickness (cm)	Multiplier	AWHC (mm)	% coarse fragments adjustment (vol.)	% coarse fragments adjustment (mm)	AWHC (mm)
					Profile AWHC =	Σ	- (i)

Layering modifiers

Check box if soil profile information above meets the criteria for one of the layering modifiers for a 15 mm upgrade.

Impermeable layer	☐	-
Coarse over fine material stratification	☐	-
Fine over coarse material stratification	☐	-
Layering effect =		**0** (ii)

Subclass 'O' where ≥15 cm O horizon beginning at 0 cm (reclaimed soils).

Subclass 'P' where % coarse fragments adjustment is ≥30 mm

Subclass 'Z' where R, KC, IMP, or i horizon occupies ≥30 cm of the profile.

Landscape Modifiers (≥10% slopes)

Aspect (degree range)	Crest 1	Upper 2	Mid 3	Lower 4		
NW-NE (316-45)	-15	0	+15	+15		
NE-SE (46-135)	-15	-15	0	0		
SE-SW (136-225)	-15	-30	-30	-30		
SW-NW (226-315)	-15	-15	0	0	**0**	(iii)

Circle applicable slope and aspect combination; toe, depression and level = 0.

Adjusted AWHC

Adjusted AWHC = (i) + (ii) + (iii) = 0 (i) + 0 (ii) + 0 (iii) = 0

Moisture regime	SMR Index and Subclass	Adjusted AWHC (mm 100cm^{-1})
Very xeric (1)	10X	< 56
Xeric (2)	24X	56 – 85
Subxeric (3)	38X	86 – 115
Submesic (4)	52	116 – 145
Mesic (5)	66	146 – 175

SMR, SMR index and Subclass

Soil Moisture Regime	**Subhydric**
SMR Index	**0**
Subclass	**W**

SOIL NUTRIENT REGIME INDEX AND SUBCLASS DETERMINATION

Total C, N and C:N

Horizon Designation	Depth (cm)	Horizon thickness (cm)	Bulk density (Mg m^{3})	TOC (%)	TOC (Mg ha^{-1})	Total Nitrogen (%)	Total Nitrogen (Mg ha^{-1})
Om	0 – 20	20	0.2	30	**120**	2	**4**
				Σ	**120**	**Σ**	**4**
				C:N	**= 120/4 = 30**		

Nutrient retention rating

Horizon Designation	Depth (cm)	Horizon thickness (cm)	Texture	Assigned rating	Weighted average calculation
Om1	0 - 20	20	-	0	TS = 0
Om2	20 - 50+	30	-	0	US = 0
					Σ = 0 + 0 = 0

Cumulative rating

Parameter		Value				Rating
Organic Carbon	(Mg ha^{-1})	120				6
Total Nitrogen	(Mg ha^{-1})	4				4
C/N ratio		30				4
Nutrient Retention[1]		TS	0	US	0	0

[1] Weighted average calculation may be required.

Cumulative rating	Σ	14
Soil Nutrient Regime Index and Subclass	SNR	10

Base rating

Base Rating = SMR Index + SNR Index = SMR Index (0) + SNR index (10) = **10** (a)

Subclass(es) = W

LIMITING FACTOR DEDUCTIONS

Weighted average calculations must be performed as required.

Topsoil Adjustment (0-20 cm)

Factor		Value	Deduction	Subclass
Structure/Consistence		-	0 %	D
Reaction	pH	4.5	15 %	V
Salinity	EC (dS m^{-1})	0.46	0 %	N
Sodicity	SAR	0.17	0 %	Y

TS deduction (b) **(b)** = (most limiting of D, V, N, Y%)(a)

(b) = (15)(a) = **1.5** **(b)**

Interim soil rating (c) **(c)** = (a) – (b)

(c) = (10) - (1.5) = 8.5 **(c)**

Upper Subsoil Adjustment (20-50 cm)

Factor		Value	Deduction	Subclass
Structure/Consistence		-	0 %	D
Reaction	pH	5.0	**15 %**	V
Salinity	EC (dS m^{-1})	0.23	0 %	N
Sodicity	SAR	0.25	0 %	Y

US deduction (d) **(d)** = (most limiting of D, V, N, Y%)(c) (0.67)

(d) = (15)(8.5)(0.67) = **0.9** **(d)**

Lower Subsoil Adjustment (50-100 cm)

Factor		Value	Deduction	Subclass
Structure/Consistence		50-60cm=(20%)(0% ded)=0% 60-100cm=(80%)(20% ded)=16%	**16 %**	D
Reaction	pH	50-60cm=(20%)(15% ded)=3% 60-100cm=(80%)(0% ded)=0%	3 %	V
Salinity	EC (dS m^{-1})	0.46	0 %	N
Sodicity	SAR	0.17	0 %	Y

LS deduction (e) **(e)** = (most limiting of D, V, N, Y%)(c) (0.33)

(e) = (16)(8.5)(0.33) = **0.4** **(e)**

Final Land rating = (a) – (b) – (d) – (e)

Final Land Rating = (**10**) – (**1.5**) – (**0.9**) – (**0.4**) = **7.2**

Land capability rating ranges	Land capability class
81-100	Class 1
61-80	Class 2
41-60	Class 3
21-40	Class 4
0-20	Class 5

Land capability rating:	**7.2**
Land capability class:	**5**
Subclass(es):	**W**

Site and Soil Description Form

Location/Site	*6*	Assessment date	*May 24, 2006*	
Map Unit/Soil Series	***Peat-mix / Mineral / Tailings sand***	Assessor(s)	*CEMA*	
Soil Classification	***Soil Series A***	Ecosite	a b c d e f g h i j k l	
Parent Material	Genetic: *N/A* Expression: ***Inclined***	Type	Natural ☐ Reclaimed ☐☑	
Drainage	VR R [*W*] MW I P VP	Site Index and Species	Species: *N/A* Height: - Age: -	Site Index: *N/A*
Soil Moisture Regime	1 2 3 4 [*5*] 6 7a 7b 8 9	Stand Quality	High [*Moderate*] Low Non-Productive	
Soil Nutrient Regime	P [*M*] R	Compaction	[*None*] Sli Mod Sev V.Sev Ext	
Topography	Percent: *3* Position: ***Midslope (C)*** Aspect: ***270° (West)***	Notes:		
Coarse Fragments (% vol. to 1 m)	Gravel: *5%* Stones: *0%*			
Depth to water table (cm)	*>100*			
Samples	*3*			

Horizon	Depth	Color	Texture	Structure			Consistence	Mottles			Impermeable	Coarse Fragments (%)	Sample ID
				Grade	Size (mm)	Kind		Abundance	Size	Contrast			
Ptmix	0-13	10YR 2/2m	Ptmix	W	2-5	GR	Very friable	-	-	-	-	5	6 – Ptmix
MIN	13-47	10YR 4/2m	C	M	20-50	SBK	Firm	-	-	-	-	2	6 – MIN
TSS	47-100	10YR 5/3m	S	-	-	SG	Loose	-	-	-	-	<2	6 - TSS

Analytical results

Site Id	Sample ID	Thickness (cm)	TOC (%)	Total nitrogen (%)	Bulk density (Mg m^{-3})	Clay (%)	Sand (%)	Silt (%)	Texture	pH (H_2O)	EC (dS m^{-1})	SAR
6	6 – Ptmix	13	6.32	0.21	0.46	4	92	4	S	7.2	1.22	0.2
6	6 – MIN	34	0.5	0.05	1.58	45	29	26	C	7.7	1.13	1.1
6	6–TSS	53	-	-	1.71	3	95	2	S	8.1	0.21	0.8

LAND CAPABILITY WORKSHEET

SOIL MOISTURE REGIME INDEX AND SUBCLASS DETERMINATION

Water table ≤100 cm[1]

Moisture regime	SMR Index and Subclass	Description	Surface organic thickness (cm)	Water table depth (cm)
Subhygric (6)[2]	80	Water removed slowly enough to keep the soil wet for a significant part of the growing season; some temporary seepage and possible mottling below 20 cm.	10 - 40	May be <100
Hygric (7a)[2]	66	Hygric aerated: Water removed slowly enough to keep the soil wet for most of the growing season; mottling present within 50 cm.	16 - 40	30-100
Hygric (7r)[2]	24W	Hygric reduced: Water removed slowly enough to keep the soil wet for most of the growing season; >50% gley within 50 cm.	16 - 40	30-100
Subhydric (8)	0W	Water removed slowly enough to keep the water table at or near surface for most of the year; organic and gleyed mineral soils; permanent seepage < 30 cm below soil surface.	> 40	0-30
Hydric (9)	0W	Water removed so slowly that the water table is at or above the soil surface all year; organic and gleyed mineral soils.	> 40	0+

[1] Circle the appropriate SMR index and subclass based on soil and landscape description, surface organic thickness, and water table depth.

[2] Subhygric and hygric moisture reqimes are not to be applied to reclaimed soils at this time.

Note: additional indicators can be found in Table 9.

AWHC Calculation (water table >100 cm; no gleying)

Horizon Designation	Texture	Horizon Thickness (cm)	Multiplier	AWHC (mm)	% coarse fragments adjustment (vol.)	% coarse fragments adjustment (mm)	AWHC (mm)
Ptmix	S	13	1.2	16	5	-	16
MIN	C	34	1.6	54	2	-	54
TSS	S	53	1.0	53	<2	-	53
					Profile AWHC =	Σ	123 (i)

Layering modifiers

Check box if soil profile information above meets the criteria for one of the layering modifiers for a 15 mm upgrade.

Impermeable layer	☐	-
Coarse over fine material stratification	☐	-
Fine over coarse material stratification	☐	-
Layering effect =		**0** (ii)

Subclass 'O' where ≥15 cm O horizon beginning at 0 cm (reclaimed soils).

Subclass 'P' where % coarse fragments adjustment is ≥30 mm

Subclass 'Z' where R, KC, IMP, or i horizon occupies ≥30 cm of the profile.

Landscape Modifiers (≥10% slopes)

Aspect (degree range)	Crest 1	Upper 2	Mid 3	Lower 4		
NW-NE (316-45)	-15	0	+15	+15		
NE-SE (46-135)	-15	-15	0	0		
SE-SW (136-225)	-15	-30	-30	-30		
SW-NW (226-315)	-15	-15	0	0	**0**	(iii)

Circle applicable slope and aspect combination; toe, depression and level = 0.

Adjusted AWHC

Adjusted AWHC = (i) + (ii) + (iii) = 123 (i) + 0 (ii) + 0 (iii) = 123

Moisture regime	SMR Index and Subclass	Adjusted AWHC (mm 100cm^{-1})
Very xeric (1)	10X	< 56
Xeric (2)	24X	56 – 85
Subxeric (3)	38X	86 – 115
Submesic (4)	52	116 – 145
Mesic (5)	66	146 – 175

SMR, SMR index and Subclass

Soil Moisture Regime	**Submesic**
SMR Index	**52**
Subclass	

SOIL NUTRIENT REGIME INDEX AND SUBCLASS DETERMINATION

Total C, N and C:N

Horizon Designation	Depth (cm)	Horizon thickness (cm)	Bulk density (Mg m^3)	TOC (%)		TOC (Mg ha^{-1})	Total Nitrogen (%)		Total Nitrogen (Mg ha^{-1})
Ptmix	0-13	13	0.46	6.32		**38**	0.21		**1.3**
MIN	13-47	34	1.58	0.5		**5.5**	0.05		**0.6**
TSS	47-100	53	1.71	-		-	-		-
					Σ	**43**		Σ	**1.9**
					C:N	**= 43/1.9 = 23**			

Nutrient retention rating

Horizon Designation	Depth (cm)	Horizon thickness (cm)	Texture	Assigned rating	Weighted average calculation
Ptmix	0-13	13	S	0	
MIN	13-47	34	C	3	TS = 13/20 x (0) + 7/20 x (3) = 1
TSS	47-100	53	S	0	US = 37/30 x (3) + 3/30 x (0) = 3
					Σ = 1 + 3 = 4

Cumulative rating

Parameter		Value					Rating
Organic Carbon	(Mg ha^{-1})	43					4
Total Nitrogen	(Mg ha^{-1})	1.9					2
C/N ratio		23					4
Nutrient Retention[1]		TS	1	US	3		4

[1] Weighted average calculation may be required.

Cumulative rating	Σ	14
Soil Nutrient Regime Index and Subclass	SNR	10

Base rating

Base Rating = SMR Index + SNR Index = SMR Index 52 + SNR index 10 = 62 (a)

Subclass(es) =

LIMITING FACTOR DEDUCTIONS

Weighted average calculations must be performed as required.

Topsoil Adjustment (0-20 cm)

Factor		Value	Deduction	Subclass
Structure/Consistence		0-13cm=(65%)(0% ded.)=0% 13-20cm=(35%)(30% ded.)=11%	11 %	D
Reaction	pH	0-13cm=(65%)(10% ded.)=6.5% 13-20cm=(35%)(25% ded)=8.75%	15 %	V
Salinity	EC (dS m^{-1})	1.22	0 %	N
Sodicity	SAR	0.2	0 %	Y

TS deduction (b) **(b)** = (most limiting of D, V, N, Y%)(a)

(b) = (15)(a) = 9.3 **(b)**

Interim soil rating (c) **(c)** = (a) – (b)

(c) = (62) - (9.3) = 52.7 **(c)**

Upper Subsoil Adjustment (20-50 cm)

Factor		Value	Deduction	Subclass
Structure/Consistence		20-47cm=(90%)(30% ded.)=23% 47-50cm=(10%)(0% ded.)=0%	27 %	D
Reaction	pH	20-47cm=(90%)(20% ded.)=18% 47-50cm=(10%)(40% ded.)=4%	22 %	V
Salinity	EC (dS m^{-1})	1.13	0 %	N
Sodicity	SAR	1.1	0 %	Y

US deduction (d) **(d)** = (most limiting of D, V, N, Y%)(c) (0.67)

(d) = (27)(52.7)(0.67) = **9.5** **(d)**

Lower Subsoil Adjustment (50-100 cm)

Factor		Value	Deduction	Subclass
Structure/Consistence		50-100cm=(100%)(0%ded)=0%	0 %	D
Reaction	pH	8.1	40 %	V
Salinity	EC (dS m^{-1})	0.21	0 %	N
Sodicity	SAR	0.8	0 %	Y

LS deduction (e) **(e)** = (most limiting of D, V, N, Y%)(c) (0.33)

(e) = (40)(52.7)(0.33) = **7.0** **(e)**

Final Land rating = (a) – (b) – (d) – (e)

Final Land Rating = (**62**) – (**9.3**) – (**9.5**) – (**7.0**) = **36.2**

Land capability rating ranges	Land capability class
81-100	Class 1
61-80	Class 2
41-60	Class 3
21-40	Class 4
0-20	Class 5

Land capability rating:	**36**
Land capability class:	**4**
Subclass(es):	**DV**

Site and Soil Description Form

Location/Site	*7*	Assessment date	***May 24, 2006***	
Map Unit/Soil Series	***Direct Placement / Tailings sand***	Assessor(s)	***CEMA***	
Soil Classification	***Soil Series B***	Ecosite	a b c d e f g h i j k l	
Parent Material	Genetic: ***N/A*** Expression: ***Inclined***	Type	Natural ☐ Reclaimed ☐☑	
Drainage	VR R [W] MW I P VP	Site Index and Species	Species: ***N/A*** Height: - Age: -	Site Index: ***N/A***
Soil Moisture Regime	1 2 3 4 [5] 6 7a 7b 8 9	Stand Quality	High [***Moderate***] Low Non-Productive	
Soil Nutrient Regime	P [M] R	Compaction	[***None***] Sli Mod Sev V.Sev Ext	
Topography	Percent: ***18*** Position: ***Midslope (C)*** Aspect: ***0° (North)***	Notes:		
Coarse Fragments (% vol. to 1 m)	Gravel: ***5%*** Stones: ***0%***			
Depth to water table (cm)	***>100***			
Samples	***3***			

Horizon	Depth	Color	Texture	Structure			Consistence	Mottles			Impermeable	Coarse Fragments (%)	Sample ID
				Grade	Size (mm)	Kind		Abundance	Size	Contrast			
MIN	0-20	10YR 3/2m	L	W	2-5	GR	Very friable	-	-	-	-	5	7–MIN(TS)
MIN	20-46	10YR 3/2m	L	M	5-10	SBK	Friable	-	-	-	-	5	7-MIN(US)
TSS	46-100	10YR 5/3m	S	-	-	SG	Loose	-	-	-	-	<2	7 – TSS

Analytical results

Site Id	Sample ID	Thickness (cm)	TOC (%)	Total nitrogen (%)	Bulk density ($Mg\ m^{-3}$)	Clay (%)	Sand (%)	Silt (%)	Texture	pH (H_2O)	EC ($dS\ m^{-1}$)	SAR
7	7–MIN(TS)	20	1.61	0.08	1.31	24	44	32	L	7.4	1.69	0.6
7	7–MIN(US)	26	-	-	1.45	21	50	29	L	6.0	3.34	1.4
7	7–TSS	54	-	-	1.60	3	91	6	S	7.5	0.45	0.5

LAND CAPABILITY WORKSHEET

SOIL MOISTURE REGIME INDEX AND SUBCLASS DETERMINATION

Water table ≤100 cm[1]

Moisture regime	SMR Index and Subclass	Description	Surface organic thickness (cm)	Water table depth (cm)
Subhygric (6)[2]	80	Water removed slowly enough to keep the soil wet for a significant part of the growing season; some temporary seepage and possible mottling below 20 cm.	10 - 40	May be <100
Hygric (7a)[2]	66	Hygric aerated: Water removed slowly enough to keep the soil wet for most of the growing season; mottling present within 50 cm.	16 - 40	30-100
Hygric (7r)[2]	24W	Hygric reduced: Water removed slowly enough to keep the soil wet for most of the growing season; >50% gley within 50 cm.	16 - 40	30-100
Subhydric (8)	0W	Water removed slowly enough to keep the water table at or near surface for most of the year; organic and gleyed mineral soils; permanent seepage < 30 cm below soil surface.	> 40	0-30
Hydric (9)	0W	Water removed so slowly that the water table is at or above the soil surface all year; organic and gleyed mineral soils.	> 40	0+

[1] Circle the appropriate SMR index and subclass based on soil and landscape description, surface organic thickness, and water table depth.

[2] Subhygric and hygric moisture regimes are not to be applied to reclaimed soils at this time.

Note: additional indicators can be found in Table 9.

AWHC Calculation (water table >100 cm; no gleying)

Horizon Designation	Texture	Horizon Thickness (cm)	Multiplier	AWHC (mm)	% coarse fragments adjustment (vol.)	% coarse fragments adjustment (mm)	AWHC (mm)
MIN	L	46	1.5	69	5	-	69
TSS	S	54	1.0	54	<2	-	54
						Profile AWHC = Σ	123 (i)

Layering modifiers

Check box if soil profile information above meets the criteria for one of the layering modifiers for a 15 mm upgrade.

Impermeable layer	❑	-
Coarse over fine material stratification	❑	-
Fine over coarse material stratification	❑	-
Layering effect =		**0** (ii)

Subclass 'O' where ≥15 cm O horizon beginning at 0 cm (reclaimed soils).

Subclass 'P' where % coarse fragments adjustment is ≥30 mm

Subclass 'Z' where R, KC, IMP, or i horizon occupies ≥30 cm of the profile.

Landscape Modifiers (≥10% slopes)

Aspect (degree range)	Crest 1	Upper 2	Mid 3	Lower 4		
NW-NE (316-45)	-15	0	**+15**	+15		
NE-SE (46-135)	-15	-15	0	0		
SE-SW (136-225)	-15	-30	-30	-30		
SW-NW (226-315)	-15	-15	0	0	**15**	(iii)

Circle applicable slope and aspect combination; toe, depression and level = 0.

Adjusted AWHC

Adjusted AWHC = (i) + (ii) + (iii) = 123 (i) + 0 (ii) + 15 (iii) = 138

Moisture regime	SMR Index and Subclass	Adjusted AWHC (mm 100cm^{-1})
Very xeric (1)	10X	< 56
Xeric (2)	24X	56 – 85
Subxeric (3)	38X	86 – 115
Submesic (4)	52	116 – 145
Mesic (5)	66	146 – 175

SMR, SMR index and Subclass

Soil Moisture Regime	**Submesic**
SMR Index	**52**
Subclass	

SOIL NUTRIENT REGIME INDEX AND SUBCLASS DETERMINATION

Total C, N and C:N

Horizon Designation	Depth (cm)	Horizon thickness (cm)	Bulk density (Mg m^3)	TOC (%)	TOC (Mg ha^{-1})	Total Nitrogen (%)	Total Nitrogen (Mg ha^{-1})
MIN	0-20	20	1.31	1.61	**42**	0.08	**2.1**
MIN	20-46	26	1.45	-	-	-	-
TSS	46-100	54	1.60	-	-	-	-
				Σ	**42**	**Σ**	**2.1**
				C:N	**= 42/2.1 = 20**		

Nutrient retention rating

Horizon Designation	Depth (cm)	Horizon thickness (cm)	Texture	Assigned rating	Weighted average calculation
MIN	0-20	20	L	3	
MIN	20-46	26	L	3	TS = 20/20 x (3) = 3
TSS	46-100	54	S	0	US = 26/30 x (3) + 4/30 x (0) = 3
					Σ = 3 + 3 = 6

Cumulative rating

Parameter		Value				Rating
Organic Carbon	(Mg ha^{-1})	42				4
Total Nitrogen	(Mg ha^{-1})	2.1				2
C/N ratio		20				4
Nutrient Retention[1]		TS	3	US	3	6

[1] Weighted average calculation may be required.

Cumulative rating	Σ	16
Soil Nutrient Regime Index and Subclass	SNR	10

Base rating

Base Rating = SMR Index + SNR Index = SMR Index (52) + SNR index (10) = **62** (a)

Subclass(es) = ____ ____

LIMITING FACTOR DEDUCTIONS

Weighted average calculations must be performed as required.

Topsoil Adjustment (0-20 cm)

Factor		Value	Deduction	Subclass
Structure/Consistence		0-20cm=(100%)(0% ded.)=0%	0 %	D
Reaction	pH	7.4	**10 %**	V
Salinity	EC (dS m^{-1})	1.69	0 %	N
Sodicity	SAR	0.6	0 %	Y

TS deduction (b) **(b)** = (most limiting of D, V, N, Y%)(a)

(b) = (10)(a) = **6.2** **(b)**

Interim soil rating (c) **(c)** = (a) – (b)

(c) = (62) - (6.2) = 55.8 **(c)**

Upper Subsoil Adjustment (20-50 cm)

Factor		Value	Deduction	Subclass
Structure/Consistence		20-50cm=(100%)(0% ded.)=0%	0 %	D
Reaction	pH	20-46cm=(87%)(0% ded.)=0% 46-50cm=(13%)(10% ded.)=4	1.3 %	V
Salinity	EC (dS m^{-1})	20-46cm=(87%)(30% ded.)=26% 46-50cm=(13%)(0% ded.)=0	**26 %**	N
Sodicity	SAR	1.4	0 %	Y

US deduction (d) **(d)** = (most limiting of D, V, N, Y%)(c) (0.67)

(d) = (26)(55.8)(0.67) = **9.7** **(d)**

Lower Subsoil Adjustment (50-100 cm)

Factor		Value	Deduction	Subclass
Structure/Consistence		50-100cm=(100%)(0%ded)=0%	**0 %**	D
Reaction	pH	7.5	**10 %**	V
Salinity	EC (dS m^{-1})	0.45	0 %	N
Sodicity	SAR	0.5	0 %	Y

LS deduction (e) **(e)** = (most limiting of D, V, N, Y%)(c) (0.33)

(e) = (10)(55.8)(0.33) = **1.8** **(e)**

Final Land rating = (a) – (b) – (d) – (e)

Final Land Rating = (**62**) – (**6.2**) – (**9.7**) – (**1.8**) = **44.3**

Land capability rating ranges	Land capability class
81-100	Class 1
61-80	Class 2
41-60	Class 3
21-40	Class 4
0-20	Class 5

Land capability rating:	**44**
Land capability class:	**3**
Subclass(es):	**N**

Site and Soil Description Form

Location/Site	*8*	Assessment date	*May 24, 2006*	
Map Unit/Soil Series	***Peat-mix / Mineral / Overburden***	Assessor(s)	*CEMA*	
Soil Classification	***Soil Series E***	Ecosite	a b c d e f g h i j k l	
Parent Material	Genetic: ***N/A*** Expression: ***Inclined***	Type	Natural ☐ Reclaimed ☐☑	
Drainage	VR R [W] MW I P VP	Site Index and Species	Species: ***Jack Pine*** Height: ***2.9 m*** Age: ***5***	Site Index: ***16***
Soil Moisture Regime	1 2 3 4 [5] 6 7a 7b 8 9	Stand Quality	High [*Moderate*] Low Non-Productive	
Soil Nutrient Regime	[P] M R	Compaction	[*None*] Sli Mod Sev V.Sev Ext	
Topography	Percent: ***18*** Position: ***Upper (B)*** Aspect: ***180° (South)***	Notes:		
Coarse Fragments (% vol. to 1 m)	Gravel: ***5%*** Stones: ***0%***			
Depth to water table (cm)	***>100***			
Samples	***3***			

Horizon	Depth	Color	Texture	Structure			Consistence	Mottles			Impermeable	Coarse Fragments (%)	Sample ID
				Grade	Size (mm)	Kind		Abundance	Size	Contrast			
Ptmix	0-11	10YR 2/2m	Ptmix	W	2-5	GR	Friable	-	-	-	-	5	8 – Ptmix
MIN	11-79	10YR 3/3m	SCL	M	10-20	SBK	Firm	-	-	-	-	5	8 - MIN
KM	79-100	10YR 3/1m	SL	-	50-100	MA	Very firm	-	-	-	Yes	5	8 – KM

Analytical results

Site Id	Sample ID	Thickness (cm)	TOC (%)	Total nitrogen (%)	Bulk density ($Mg\ m^{-3}$)	Clay (%)	Sand (%)	Silt (%)	Texture	pH (H_2O)	EC ($dS\ m^{-1}$)	SAR
8	8 – Ptmix	11	10.7	0.13	0.56	4	92	4	S	7.4	0.63	0.1
8	8 – MIN	68	0.5	0.03	1.49	29	46	25	SCL	7.4	0.66	0.2
8	8 – KM	21	-	-	1.79	15	65	20	SL	7.2	1.75	0.3

LAND CAPABILITY WORKSHEET

SOIL MOISTURE REGIME INDEX AND SUBCLASS DETERMINATION

Water table ≤100 cm[1]

Moisture regime	SMR Index and Subclass	Description	Surface organic thickness (cm)	Water table depth (cm)
Subhygric (6)[2]	80	Water removed slowly enough to keep the soil wet for a significant part of the growing season; some temporary seepage and possible mottling below 20 cm.	10 - 40	May be <100
Hygric (7a)[2]	66	Hygric aerated: Water removed slowly enough to keep the soil wet for most of the growing season; mottling present within 50 cm.	16 - 40	30-100
Hygric (7r)[2]	24W	Hygric reduced: Water removed slowly enough to keep the soil wet for most of the growing season; >50% gley within 50 cm.	16 - 40	30-100
Subhydric (8)	0W	Water removed slowly enough to keep the water table at or near surface for most of the year; organic and gleyed mineral soils; permanent seepage < 30 cm below soil surface.	> 40	0-30
Hydric (9)	0W	Water removed so slowly that the water table is at or above the soil surface all year; organic and gleyed mineral soils.	> 40	0+

[1] Circle the appropriate SMR index and subclass based on soil and landscape description, surface organic thickness, and water table depth.

[2] Subhygric and hygric moisture regimes are not to be applied to reclaimed soils at this time.

Note: additional indicators can be found in Table 9.

AWHC Calculation (water table >100 cm; no gleying)

Horizon Designation	Texture	Horizon Thickness (cm)	Multiplier	AWHC (mm)	% coarse fragments adjustment (vol.)	% coarse fragments adjustment (mm)	AWHC (mm)
Ptmix	S	11	1.2	69	5	-	13
MIN	SCL	68	1.5	54	5	-	102
KM	SL	21	0.0	-			-
						Profile AWHC = Σ	115 (i)

Layering modifiers

Check box if soil profile information above meets the criteria for one of the layering modifiers for a 15 mm upgrade.

Impermeable layer	❑	-
Coarse over fine material stratification	❑	-
Fine over coarse material stratification	❑	-
Layering effect =		0 (ii)

Subclass 'O' where ≥15 cm O horizon beginning at 0 cm (reclaimed soils).

Subclass 'P' where % coarse fragments adjustment is ≥30 mm

Subclass 'Z' where R, KC, IMP, or i horizon occupies ≥30 cm of the profile.

Landscape Modifiers (≥10% slopes)

Aspect (degree range)	Crest 1	Upper 2	Mid 3	Lower 4		
NW-NE (316-45)	-15	0	+15	+15		
NE-SE (46-135)	-15	-15	0	0		
SE-SW (136-225)	-15	***-30***	-30	-30		
SW-NW (226-315)	-15	-15	0	0	**-30**	(iii)

Circle applicable slope and aspect combination; toe, depression and level = 0.

Adjusted AWHC

Adjusted AWHC = (i) + (ii) + (iii) = 115 (i) + 0 (ii) + -30 (iii) = **85**

Moisture regime	SMR Index and Subclass	Adjusted AWHC (mm 100cm^{-1})
Very xeric (1)	10X	< 56
Xeric (2)	24X	56 – 85
Subxeric (3)	38X	86 – 115
Submesic (4)	52	116 – 145
Mesic (5)	66	146 – 175

SMR, SMR index and Subclass

Soil Moisture Regime	**Subxeric**
SMR Index	**24**
Subclass	**X**

SOIL NUTRIENT REGIME INDEX AND SUBCLASS DETERMINATION

Total C, N and C:N

Horizon Designation	Depth (cm)	Horizon thickness (cm)	Bulk density (Mg m^3)	TOC (%)		TOC (Mg ha^{-1})	Total Nitrogen (%)		Total Nitrogen (Mg ha^{-1})
Ptmix	0-11	11	0.56	10.7		**65.9**	0.13		**0.8**
MIN	11-79	68	1.49	0.5		**6.7**	0.03		**0.4**
KM	79-100	21	1.79	-		-	-		-
					Σ	**73**		**Σ**	**1.2**
					C:N	**= 73/1.2 = 61**			

Nutrient retention rating

Horizon Designation	Depth (cm)	Horizon thickness (cm)	Texture	Assigned rating	Weighted average calculation
Ptmix	0-11	11	S	0	
MIN	11-79	68	SCL	3	TS = 11/20 x (0) + 9/20 x (3) = 1
KM	79-100	21	SL	0	US = 30/30 x (3) = 3
					Σ = 3 + 3 = 6

Cumulative rating

Parameter		Value				Rating
Organic Carbon	(Mg ha^{-1})	73				6
Total Nitrogen	(Mg ha^{-1})	1.2				2
C/N ratio		61				2
Nutrient Retention[1]		TS	1	US	3	4

[1] Weighted average calculation may be required.

Cumulative rating	Σ	14
Soil Nutrient Regime Index and Subclass	SNR	10

Base rating

Base Rating = SMR Index + SNR Index = SMR Index (24) + SNR index (10) = **34** (a)

Subclass(es) = X

LIMITING FACTOR DEDUCTIONS

Weighted average calculations must be performed as required.

Topsoil Adjustment (0-20 cm)

Factor		Value	Deduction	Subclass
Structure/Consistence		0-11cm=(55%)(0% ded.)=0% 11-20cm=(45%)(15% ded.)=0%	6.75 %	D
Reaction	pH	7.4	**10 %**	V
Salinity	EC (dS m^{-1})	0.63	0 %	N
Sodicity	SAR	0.1	0 %	Y

TS deduction (b) **(b) = (most limiting of D, V, N, Y%)(a)**

(b) = (10)(a) = 3.4 (b)

Interim soil rating (c) **(c) = (a) – (b)**

(c) = (34) - (3.4) = 30.6 (c)

Upper Subsoil Adjustment (20-50 cm)

Factor		Value	Deduction	Subclass
Structure/Consistence		20-50cm=(100%)(10% ded.)=10%	**10 %**	D
Reaction	pH	7.4	**10 %**	V
Salinity	EC (dS m^{-1})	0.66	0 %	N
Sodicity	SAR	0.2	0 %	Y

US deduction (d) **(d) = (most limiting of D, V, N, Y%)(c) (0.67)**

(d) = (10)(30.6)(0.67) = 2.1 (d)

Lower Subsoil Adjustment (50-100 cm)

Factor		Value	Deduction	Subclass
Structure/Consistence		50-79cm=(58%)(10%ded)=6% 79-100cm=(42%)(40%ded)=17%	**23 %**	D
Reaction	pH	50-79cm=(58%)(10%ded)=10% 79-100cm=(42%)(10%ded)=10%	10 %	V
Salinity	EC (dS m^{-1})	1.75	0 %	N
Sodicity	SAR	0.3	0 %	Y

LS deduction (e) **(e) = (most limiting of D, V, N, Y%)(c) (0.33)**

(e) = (23)(30.6)(0.33) = 2.3 (e)

Final Land rating = (a) – (b) – (d) – (e)

Final Land Rating = (**34**) – (**3.4**) – (**2.1**) – (**2.3**) = **26.2**

Land capability rating ranges	Land capability class
81-100	Class 1
61-80	Class 2
41-60	Class 3
21-40	Class 4
0-20	Class 5

Land capability rating:	**26**
Land capability class:	**4**
Subclass(es):	**DX**

Site and Soil Description Form

Location/Site	*9*	Assessment date	*May 24, 2006*	
Map Unit/Soil Series	***Peat- mix / Tailings sand***	Assessor(s)	***CEMA***	
Soil Classification	***Soil Series H***	Ecosite	a b c d e f g h i j k l	
Parent Material	Genetic: ***N/A*** Expression: ***Inclined***	Type	Natural ☐ Reclaimed ☐☑	
Drainage	VR [R] W MW I P VP	Site Index and Species	Species: ***Jack Pine*** Height: ***2.7 m*** Age: ***3***	Site Index: ***19***
Soil Moisture Regime	1 2 3 [4] 5 6 7a 7b 8 9	Stand Quality	High Moderate [Low] Non-Productive	
Soil Nutrient Regime	P M [R]	Compaction	[None] Sli Mod Sev V.Sev Ext	
Topography	Percent: ***37*** Position: ***Upper (B)*** Aspect: ***0° (North)***	Notes:		
Coarse Fragments (% vol. to 1 m)	Gravel: ***2%*** Stones: ***0%***			
Depth to water table (cm)	***>100***			
Samples	***3***			

Horizon	Depth	Color	Texture	Structure			Consistence	Mottles			Impermeable	Coarse Fragments (%)	Sample ID
				Grade	Size (mm)	Kind		Abundance	Size	Contrast			
Ptmix	0-15	10YR 2/2m	Ptmix	W	<2	GR	Very friable	-	-	-	-	2	9 – Ptmix
TSS	15-50	10YR 5/3m	S	-	-	SG	Loose	-	-	-	-	<2	9–TSS(US)
TSS	50-100	10YR 5/3m	S	-	-	SG	Loose	-	-	-	-	<2	9–TSS(LS)

Analytical results

Site Id	Sample ID	Thickness (cm)	TOC (%)	Total nitrogen (%)	Bulk density ($Mg\ m^{-3}$)	Clay (%)	Sand (%)	Silt (%)	Texture	pH (H_2O)	EC ($dS\ m^{-1}$)	SAR
9	9 – Ptmix	15	4.49	0.43	1.33	35	35	30	CL	7.6	0.75	0.1
9	9–TSS(US)	35	0.1	0.06	1.69	3	96	1	S	8.0	0.31	0.1
9	9–TSS(LS)	50	-	-	1.58	3	96	1	S	8.0	0.28	0.3

LAND CAPABILITY WORKSHEET

SOIL MOISTURE REGIME INDEX AND SUBCLASS DETERMINATION

Water table ≤100 cm[1]

Moisture regime	SMR Index and Subclass	Description	Surface organic thickness (cm)	Water table depth (cm)
Subhygric (6)[2]	80	Water removed slowly enough to keep the soil wet for a significant part of the growing season; some temporary seepage and possible mottling below 20 cm.	10 - 40	May be <100
Hygric (7a)[2]	66	Hygric aerated: Water removed slowly enough to keep the soil wet for most of the growing season; mottling present within 50 cm.	16 - 40	30-100
Hygric (7r)[2]	24W	Hygric reduced: Water removed slowly enough to keep the soil wet for most of the growing season; >50% gley within 50 cm.	16 - 40	30-100
Subhydric (8)	0W	Water removed slowly enough to keep the water table at or near surface for most of the year; organic and gleyed mineral soils; permanent seepage < 30 cm below soil surface.	> 40	0-30
Hydric (9)	0W	Water removed so slowly that the water table is at or above the soil surface all year; organic and gleyed mineral soils.	> 40	0+

[1] Circle the appropriate SMR index and subclass based on soil and landscape description, surface organic thickness, and water table depth.

[2] Subhygric and hygric moisture reqimes are not to be applied to reclaimed soils at this time.

Note: additional indicators can be found in Table 9.

AWHC Calculation (water table >100 cm; no gleying)

Horizon Designation	Texture	Horizon Thickness (cm)	Multiplier	AWHC (mm)	% coarse fragments adjustment (vol.)	% coarse fragments adjustment (mm)	AWHC (mm)
Ptmix	CL	15	1.7	26	2	-	26
TSS	S	85	1.0	85	<2	-	85
						Profile AWHC = Σ	111 (i)

Layering modifiers

Check box if soil profile information above meets the criteria for one of the layering modifiers for a 15 mm upgrade.

Impermeable layer	☐	-
Coarse over fine material stratification	☐	-
Fine over coarse material stratification	☐	-
Layering effect =		0 (ii)

Subclass 'O' where ≥15 cm O horizon beginning at 0 cm (reclaimed soils).

Subclass 'P' where % coarse fragments adjustment is ≥30 mm

Subclass 'Z' where R, KC, IMP, or i horizon occupies ≥30 cm of the profile.

Landscape Modifiers (≥10% slopes)

Aspect (degree range)	Crest 1	Upper 2	Mid 3	Lower 4		
NW-NE (316-45)	-15	0	+15	+15		
NE-SE (46-135)	-15	-15	0	0		
SE-SW (136-225)	-15	-30	-30	-30		
SW-NW (226-315)	-15	-15	0	0	**0**	(iii)

Circle applicable slope and aspect combination; toe, depression and level = 0.

Adjusted AWHC

Adjusted AWHC = (i) + (ii) + (iii) = 111 (i) + 0 (ii) + 0 (iii) = 111

Moisture regime	SMR Index and Subclass	Adjusted AWHC (mm 100cm^{-1})
Very xeric (1)	10X	< 56
Xeric (2)	24X	56 – 85
Subxeric (3)	38X	86 – 115
Submesic (4)	52	116 – 145
Mesic (5)	66	146 – 175

SMR, SMR index and Subclass

Soil Moisture Regime	**Subxeric**
SMR Index	**38**
Subclass	**X**

SOIL NUTRIENT REGIME INDEX AND SUBCLASS DETERMINATION

Total C, N and C:N

Horizon Designation	Depth (cm)	Horizon thickness (cm)	Bulk density (Mg m^{3})	TOC (%)	TOC (Mg ha^{-1})	Total Nitrogen (%)	Total Nitrogen (Mg ha^{-1})
Ptmix	0-15	15	1.33	4.49	**89.6**	0.43	**8.6**
TSS	15-50	35	1.69	0.1	**0.8**	0.06	**0.5**
TSS	50-100	50	1.58	-	-	-	-
				Σ	**90.4**		Σ **9.1**
				C:N	**= 90.4/9.1 = 10**		

Nutrient retention rating

Horizon Designation	Depth (cm)	Horizon thickness (cm)	Texture	Assigned rating	Weighted average calculation
Ptmix	0-15	15	CL	3	
TSS	15-50	35	S	0	TS = 15/20 x (3) + 5/20 x (0) = 2
TSS	50-100	50	S	0	US = 30/30 x (0) = 0
					Σ = 2 + 0 = 2

Cumulative rating

Parameter		Value				Rating
Organic Carbon	(Mg ha^{-1})	90				6
Total Nitrogen	(Mg ha^{-1})	9.1				6
C/N ratio		10				6
Nutrient Retention[1]		TS	2	US	0	2

[1] Weighted average calculation may be required.

Cumulative rating	Σ	20
Soil Nutrient Regime Index and Subclass	SNR	15

Base rating

Base Rating = SMR Index + SNR Index = SMR Index (38) + SNR index (15) = 53 (a)

Subclass(es) = X

LIMITING FACTOR DEDUCTIONS

Weighted average calculations must be performed as required.

Topsoil Adjustment (0-20 cm)

Factor		Value	Deduction	Subclass
Structure/Consistence		0-20cm=(100%)(0% ded.)=0%	0 %	D
Reaction	pH	0-20cm=(100%)(25%ded.)=25%	25 %	V
Salinity	EC (dS m^{-1})	0.75	0 %	N
Sodicity	SAR	0.1	0 %	Y

TS deduction (b) **(b)** = (most limiting of D, V, N, Y%)(a)

(b) = (25)(a) = 13.3 **(b)**

Interim soil rating (c) **(c)** = (a) – (b)

(c) = (53) - (13.3) = 39.7 **(c)**

Upper Subsoil Adjustment (20-50 cm)

Factor		Value	Deduction	Subclass
Structure/Consistence		20-50cm=(100%)(0% ded.)=0%	0 %	D
Reaction	pH	8	20 %	V
Salinity	EC (dS m^{-1})	0.31	0 %	N
Sodicity	SAR	0.1	0 %	Y

US deduction (d) **(d)** = (most limiting of D, V, N, Y%)(c) (0.67)

(d) = (20)(39.7)(0.67) = **5.3** **(d)**

Lower Subsoil Adjustment (50-100 cm)

Factor		Value	Deduction	Subclass
Structure/Consistence		50-100cm=(100%)(0%ded)=0%	0 %	D
Reaction	pH	8.0	20 %	V
Salinity	EC (dS m^{-1})	0.28	0 %	N
Sodicity	SAR	0.3	0 %	Y

LS deduction (e) **(e)** = (most limiting of D, V, N, Y%)(c) (0.33)

(e) = (20)(39.7)(0.33) = **2.6** **(e)**

Final Land rating = (a) – (b) – (d) – (e)

Final Land Rating = (**53**) – (**13.3**) – (**5.3**) – (**2.6**) = **31.8**

Land capability rating ranges	Land capability class
81-100	Class 1
61-80	Class 2
41-60	Class 3
21-40	Class 4
0-20	Class 5

Land capability rating:	**32**
Land capability class:	**4**
Subclass(es):	**XV**

Site and Soil Description Form

Location/Site	*10*	Assessment date	*May 24, 2006*	
Map Unit/Soil Series	***Peat-mix / overburden***	Assessor(s)	*CEMA*	
Soil Classification	***Soil Series 1***	Ecosite	a b c d e f g h i j k l	
Parent Material	Genetic: *N/A* Expression: ***Inclined***	Type	Natural ☐ Reclaimed ☐ ☑	
Drainage	VR R [W] MW I P VP	Site Index and Species	Species: ***White spruce*** Height: ***6.3 m*** Age: ***13***	Site Index: *22*
Soil Moisture Regime	1 2 3 [4] 5 6 7a 7b 8 9	Stand Quality	High [*Moderate*] Low Non-Productive	
Soil Nutrient Regime	P [*M*] R	Compaction	[*None*] Sli Mod Sev V.Sev Ext	
Topography	Percent: *35* Position: ***Midslope (C)*** Aspect: ***180° (South)***	Notes:		
Coarse Fragments (% vol. to 1 m)	Gravel: *2%* Stones: *0%*			
Depth to water table (cm)	*>100*			
Samples	*3*			

Horizon	Depth	Color	Texture	Structure			Consistence	Mottles			Impermeable	Coarse Fragments (%)	Sample ID
				Grade	Size (mm)	Kind		Abundance	Size	Contrast			
Ptmix	0-20	10YR 3/1m	Ptmix	W	2-5	GR	Friable	-	-	-	-	2	10 – Ptmix
OB	20-50	10YR 3/1m	SCL	W	20-50	SBK	Firm	-	-	-	-	2	10-OB(US)
OB	50-100	10YR 3/2m	SCL	W	50-100	SBK	Very firm	-	-	-	-	2	10–OB(LS)

Analytical results

Site Id	Sample ID	Thickness (cm)	TOC (%)	Total nitrogen (%)	Bulk density (Mg m^{-3})	Clay (%)	Sand (%)	Silt (%)	Texture	pH (H_2O)	EC (dS m^{-1})	SAR
10	10–Ptmix	20	3.45	0.2	1.01	11	66	23	SL	7.6	1.18	0.5
10	10–OB(US)	30	-	0.04	1.68	25	70	5	SCL	7.4	1.68	0.4
10	10–OB(LS)	50	-	-	1.71	25	70	5	SCL	7.5	2.01	0.4

LAND CAPABILITY WORKSHEET

SOIL MOISTURE REGIME INDEX AND SUBCLASS DETERMINATION

Water table ≤100 cm[1]

Moisture regime	SMR Index and Subclass	Description	Surface organic thickness (cm)	Water table depth (cm)
Subhygric (6)[2]	80	Water removed slowly enough to keep the soil wet for a significant part of the growing season; some temporary seepage and possible mottling below 20 cm.	10 - 40	May be <100
Hygric (7a)[2]	66	Hygric aerated: Water removed slowly enough to keep the soil wet for most of the growing season; mottling present within 50 cm.	16 - 40	30-100
Hygric (7r)[2]	24W	Hygric reduced: Water removed slowly enough to keep the soil wet for most of the growing season; >50% gley within 50 cm.	16 - 40	30-100
Subhydric (8)	0W	Water removed slowly enough to keep the water table at or near surface for most of the year; organic and gleyed mineral soils; permanent seepage < 30 cm below soil surface.	> 40	0-30
Hydric (9)	0W	Water removed so slowly that the water table is at or above the soil surface all year; organic and gleyed mineral soils.	> 40	0+

[1] Circle the appropriate SMR index and subclass based on soil and landscape description, surface organic thickness, and water table depth.

[2] Subhygric and hygric moisture regimes are not to be applied to reclaimed soils at this time.

Note: additional indicators can be found in Table 9.

AWHC Calculation (water table >100 cm; no gleying)

Horizon Designation	Texture	Horizon Thickness (cm)	Multiplier	AWHC (mm)	% coarse fragments adjustment (vol.)	% coarse fragments adjustment (mm)	AWHC (mm)
Ptmix	SL	20	1.7	34	2	-	34
OB	SCL	80	1.5	120	2	-	120
						Profile AWHC = Σ	154 (i)

Layering modifiers

Check box if soil profile information above meets the criteria for one of the layering modifiers for a 15 mm upgrade.

Impermeable layer	❑	-
Coarse over fine material stratification	❑	-
Fine over coarse material stratification	❑	-
Layering effect =		0 (ii)

Subclass 'O' where ≥15 cm O horizon beginning at 0 cm (reclaimed soils).

Subclass 'P' where % coarse fragments adjustment is ≥30 mm

Subclass 'Z' where R, KC, IMP, or i horizon occupies ≥30 cm of the profile.

Landscape Modifiers (≥10% slopes)

Aspect (degree range)	Crest 1	Upper 2	Mid 3	Lower 4		
NW-NE (316-45)	-15	0	+15	+15		
NE-SE (46-135)	-15	-15	0	0		
SE-SW (136-225)	-15	-30	**-30**	-30		
SW-NW (226-315)	-15	-15	0	0	**-30**	(iii)

Circle applicable slope and aspect combination; toe, depression and level = 0.

Adjusted AWHC

Adjusted AWHC = (i) + (ii) + (iii) = 154 (i) + 0 (ii) + -30 (iii) = 124

Moisture regime	SMR Index and Subclass	Adjusted AWHC (mm 100cm^{-1})
Very xeric (1)	10X	< 56
Xeric (2)	24X	56 – 85
Subxeric (3)	38X	86 – 115
Submesic (4)	52	116 – 145
Mesic (5)	66	146 – 175

SMR, SMR index and Subclass

Soil Moisture Regime	**Submesic**
SMR Index	**52**
Subclass	

SOIL NUTRIENT REGIME INDEX AND SUBCLASS DETERMINATION

Total C, N and C:N

Horizon Designation	Depth (cm)	Horizon thickness (cm)	Bulk density (Mg m^{-3})	TOC (%)		TOC (Mg ha^{-1})	Total Nitrogen (%)		Total Nitrogen (Mg ha^{-1})
Ptmix	0-20	20	1.01	3.45		**69.7**	0.2		**4.0**
OB	20-50	30	1.68	-		-	-		-
OB	50-100	50	1.71	-		-	-		-
					Σ	**70**		Σ	**4.0**
					C:N	**= 70/4.0 = 17**			

Nutrient retention rating

Horizon Designation	Depth (cm)	Horizon thickness (cm)	Texture	Assigned rating	Weighted average calculation
Ptmix	0-20	20	SL	2	
OB	20-50	30	SCL	3	TS = 20/20 x (2) = 2
OB	50-100	50	SCL	-	US = 30/30 x (3) = 3
					Σ = 2 + 3 = 5

Cumulative rating

Parameter		Value					Rating
Organic Carbon	(Mg ha^{-1})	69.7					4
Total Nitrogen	(Mg ha^{-1})	4.0					4
C/N ratio		17					4
Nutrient Retention[1]		TS	2	US	3		5

[1] Weighted average calculation may be required.

Cumulative rating	Σ	17
Soil Nutrient Regime Index and Subclass	SNR	10

Base rating

Base Rating = SMR Index + SNR Index = SMR Index (52) + SNR index (10) = **62** (a)

Subclass(es) = _____ _____

LIMITING FACTOR DEDUCTIONS

Weighted average calculations must be performed as required.

Topsoil Adjustment (0-20 cm)

Factor		Value	Deduction	Subclass
Structure/Consistence		0-20cm=(100%)(0% ded.)=0%	0 %	D
Reaction	pH	7.6	**25 %**	V
Salinity	EC (dS m^{-1})	1.18	0 %	N
Sodicity	SAR	0.5	0 %	Y

TS deduction (b) **(b)** = (most limiting of D, V, N, Y%)(a)

(b) = (**25**)(a) = **15.5** **(b)**

Interim soil rating (c) **(c)** = (a) – (b)

(c) = (62) - (15.5) = 46.5 **(c)**

Upper Subsoil Adjustment (20-50 cm)

Factor		Value	Deduction	Subclass
Structure/Consistence		20-50cm=(100%)(30% ded.)=30%	**30 %**	D
Reaction	pH	7.4	10 %	V
Salinity	EC (dS m^{-1})	1.68	0 %	N
Sodicity	SAR	0.4	0 %	Y

US deduction (d) **(d)** = (most limiting of D, V, N, Y%)(c) (0.67)

(d) = (30)(46.5)(0.67) = **9.3** **(d)**

Lower Subsoil Adjustment (50-100 cm)

Factor		Value	Deduction	Subclass
Structure/Consistence		50-100cm=(100%)(40%ded)=40%	**40 %**	D
Reaction	pH	7.5	10 %	V
Salinity	EC (dS m^{-1})	2.01	10 %	N
Sodicity	SAR	0.4	0 %	Y

LS deduction (e) **(e)** = (most limiting of D, V, N, Y%)(c) (0.33)

(e) = (40)(46.5)(0.33) = **6.1** **(e)**

Final Land rating = (a) – (b) – (d) – (e)

Final Land Rating = (**62**) – (**15.5**) – (**9.3**) – (**6.1**) = **31.1**

Land capability rating ranges	Land capability class
81-100	Class 1
61-80	Class 2
41-60	Class 3
21-40	Class 4
0-20	Class 5

Land capability rating:	**31**
Land capability class:	**4**
Subclass(es):	**DV**